

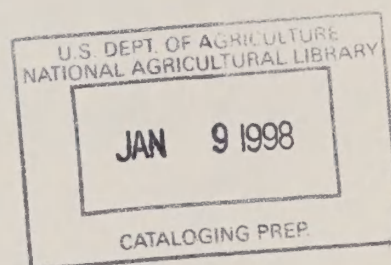
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A National Program of Research for

COTTON



Prepared by
A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES

United States
Department of
Agriculture



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FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, the adequacy of present facilities, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with the reasons which the task force believed justified them. In this particular report the deviations are large. However, as indicated by the report, the task force deliberately avoided a recommendation regarding the amount of the increased support which should come from public or industry sources.

The report represents a valuable contribution to research plans for agriculture. It will be considered by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds nor as a proposed rate at which public funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E, Administration Building, USDA, Washington, D.C. 20250.

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CONTENTS

	<u>Page</u>
Foreword -----	i
Preface -----	iii
Methods and procedures -----	iii
Members of the Joint Cotton and Cottonseed Task Force -----	iv
Introduction -----	1
Cotton's situation -----	1
Economic impact of cotton's situation -----	7
Cotton's needs in research -----	7
Opportunities for cotton research -----	9
Cotton's research difficulties -----	9
Cotton's special advantages -----	10
Cottonseed and cottonseed products -----	10
Benefits of cotton research -----	11
Summary -----	12
Research opportunities -----	12
Research opportunities -----	30
RPA 207 - Control of insect pests of field crops -----	30
RPA 208 - Control of diseases of field crops -----	43
RPA 209 - Control of weeds and other hazards of field crops ---	55
RPA 307 - Improvement of biological efficiency of field crops -	84
RPA 308 - Mechanization of production of field crops -----	92
RPA 309 - Systems analysis in production of field crops -----	101
RPA 405 - Production of field crops with improved consumer acceptability -----	108
RPA 406 - New and improved food products from field crops ----	112
RPA 407 - New and improved feed, textile, and industrial products from field crops -----	117
RPA 408 - Quality maintenance in marketing field crops -----	148
RPA 501 - Improvement of grades and standards -----	154
RPA 504 - Physical and economic efficiency in marketing field crops -----	157
Tables -----	160

PREFACE

Methods and Procedures

The Research Problem Areas assigned to the Cotton and Cottonseed Task Force were as follows:

<u>No.</u>	<u>Research Problem Area</u>	<u>1966 Research (SMY)</u>	<u>1977 LRS Recommendations (SMY)</u>
207.	Control of insect pests of field crops	91.1	107.1
208.	Control of diseases of field crops	47.6	69.6
209.	Control of weeds and other hazards of field crops	22.2	24.2
307.	Improvement of biological efficiency of field crops	98.8	184.8
308.	Mechanization of production of field crops	38.6	44.6
309.	Systems analysis in production of field crops	2.2	6.2
405.	Production of field crops with improved consumer acceptability	14.6	38.6
406.	New and improved food products from field crops	25.9	25.9
407.	New and improved feed, textile, and industrial products from field crops	145.2	170.2
408.	Quality maintenance in marketing field crops	10.6	15.6
501.	Improvement of grades and standards	3.2	7.2
504.	Physical and economic efficiency in marketing field crops	15.4	18.4
TOTAL		515.4	712.4

The general method followed in this study was to identify particular needed technological changes in the cotton and cottonseed industry, within individual Research Problem Areas, and to analyze, in depth, each of these "Research Units." "Research Approaches" to each desired technological change were studied.

Areas of research not specifically assigned to this Task Force, but having special interest for the cotton and cottonseed industry, were studied and recommendations reported separately for referral to the appropriate Task Force.

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U. S. Department of Agriculture

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INTRODUCTION

The cotton and cottonseed industry accounts for a multimillion dollar segment of the Nation's economy and represents the financial lifeblood of millions of people in the United States. The textile and fabric industry has undergone great change in recent years and continues in a state of flux. Cotton as a major component of the industry likewise is experiencing marked change. The fluctuations and trends of cotton and related use fibers, at home and abroad, are basic to an understanding of the present and potential future position of cotton for the grower and all other elements of the cotton industry. Table 1 and Charts 1, 2, and 3 depict some of the important recent changes and trends.

Cotton's Situation

Two comparisons provide the background against which cotton research must be viewed.

1. Just 25 years ago, cotton accounted for over 80 percent of all fibers consumed by American mills and man-made fibers less than 10 percent. Today mills use about as much man-made fiber as cotton. The result has been a record surplus of cotton, followed by wracking acreage reductions to restore a balance between supply and use.

Total fiber consumption in this country, however, increases by the equivalent of over one million bales of cotton a year. While cotton stands still, the synthetics have been using research--and promotion--to take virtually all of the market increase. If cotton can capture just half of the natural increase in the fiber market for only the next two years through its own research and promotion, rather than let the man-made fibers have it all, there will be \$110 million more in cash income for American cotton farmers--and a chance to plant 900,000 additional acres annually.

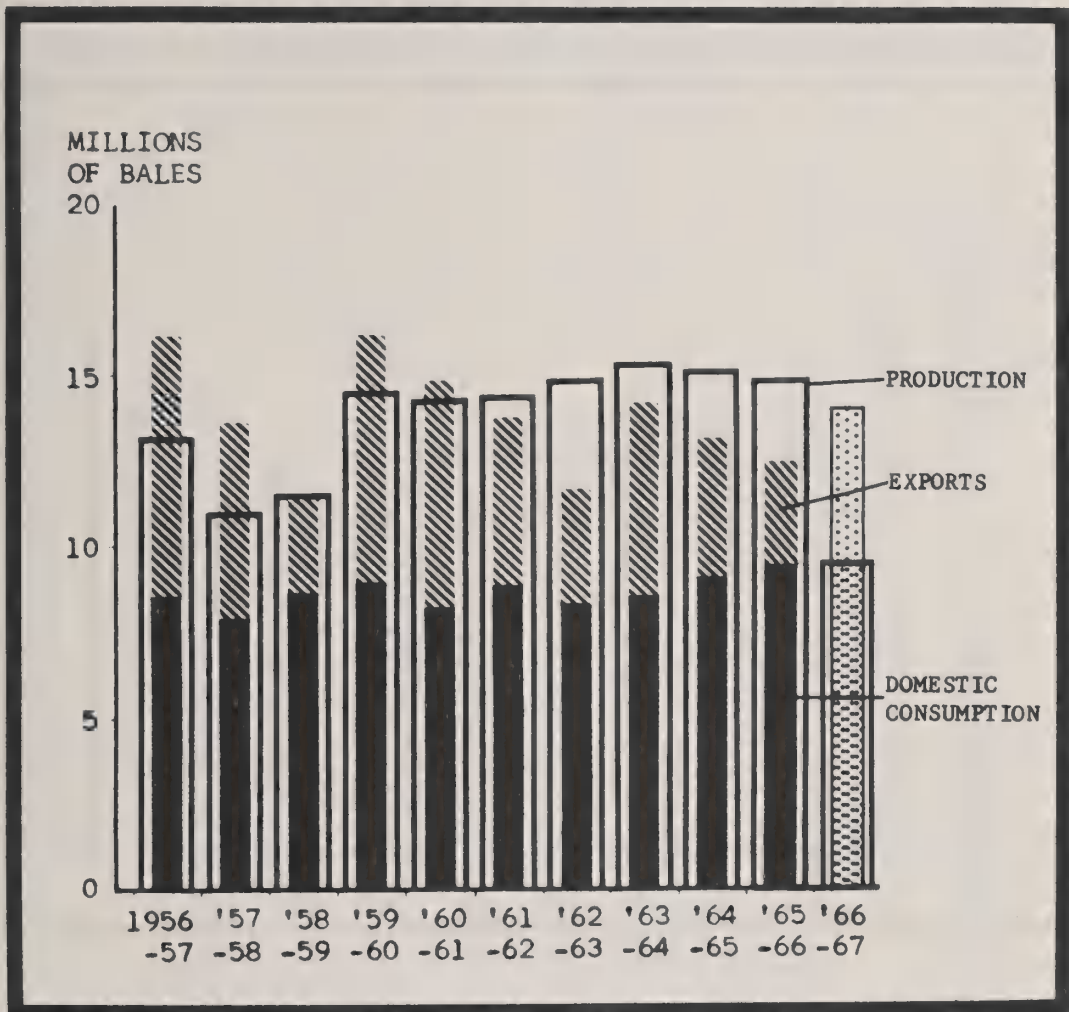
2. It costs currently on the average about 28 cents per pound to produce, harvest, and gin cotton in the U. S. Yet, cotton must sell at around 21 to 22 cents per pound to meet the price competition of rayon and foreign-grown cotton. The income gap--resulting from the difference between the average price cotton brings in the market and the average cost of producing it--has been approximately offset by Government payments. But the cost to the Government is heavy--and authorization for this program expires after the 1969 crop.

There is need for research into new program approaches. The needs of people and the communities concerned must be included as important factors in the evaluation of total costs and potential benefits of any program under consideration.

TABLE 1.--Selected changes in the U. S. cotton industry 1950 to 1965

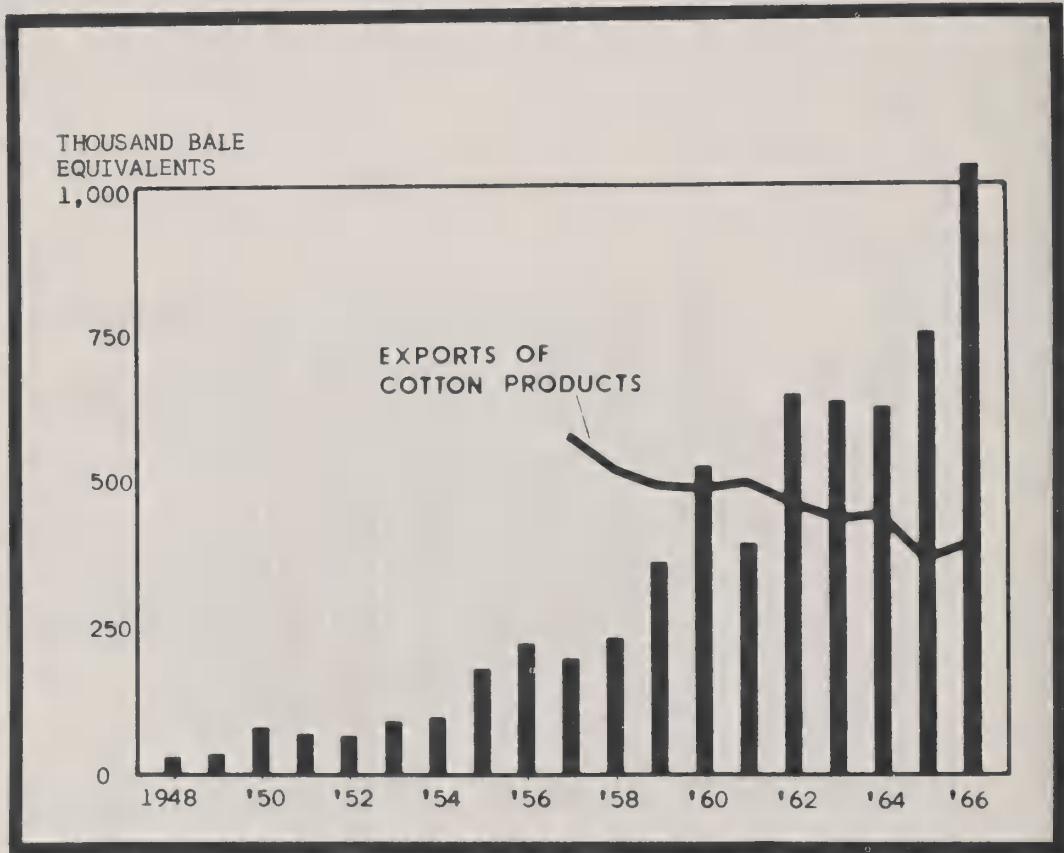
	<u>1950</u>	<u>1965</u>
Acres harvested (thousands of acres)		
U. S.	17,843	13,617
World	70,920	81,581
Yield per acre (lbs.)		
U. S.	269	526
World	211	313
Production (thousands of bales)		
U. S.	10,014	14,956
World	30,984	53,159
U. S. hand-harvested cotton (percent of total)	92	15
U. S. average price received by farmers (cents)	40.1	28.0
U. S. domestic fiber consumption per capita (lbs.)		
Cotton	29.4	24.0
Wool	4.6	2.7
Rayon and acetate	8.6	8.1
Other synthetic fibers	<u>.9</u>	<u>10.2</u>
Total	43.5	45.0
U. S. cotton imports, raw cotton equivalent (thousands of bales)		
Raw cotton	189.1	118.4
Yarn, thread and cloth	27.1	423.0
Manufactured products	<u>56.3</u>	<u>328.2</u>
Total	272.5	869.6
U. S. cotton exports, raw cotton equivalent (thousands of bales)		
Raw cotton	4,280.0	2,942.0
Yarn, thread and cloth	453.3	251.0
Manufactured products	<u>85.5</u>	<u>111.1</u>
Total	4,818.8	3,304.1

CHART 1.--Production, consumption and exports of U. S. cotton



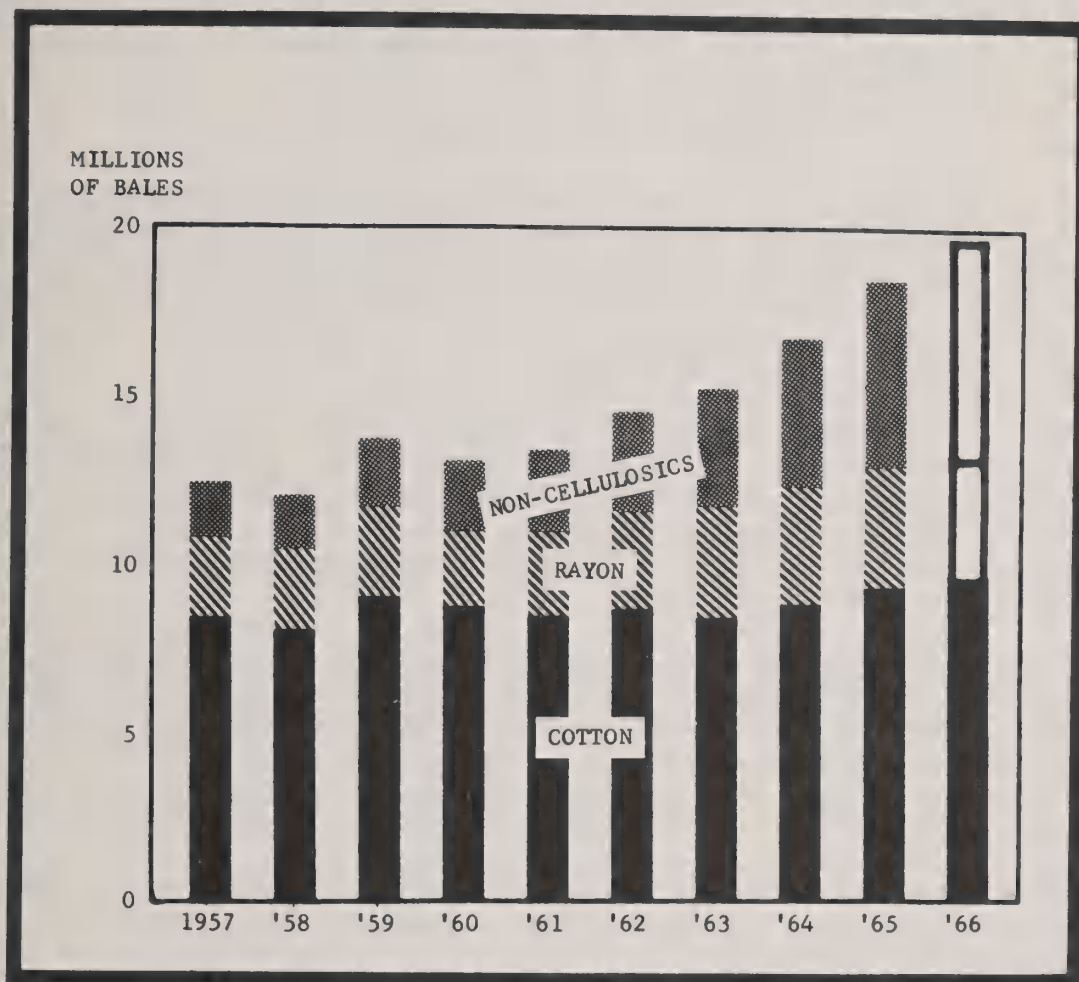
SOURCES: Consumption and exports - U.S. Department of Commerce. For 1966-67 estimates, see text. Production - U.S. Department of Agriculture.

CHART 2.--Cotton imports in manufactured form



SOURCE: U.S. Department of Agriculture.

CHART 3.--U. S. mill consumption



SOURCES: Cotton--U.S. Department of Commerce figures for running bales converted to 500 pound bale equivalent. Man-made fiber--Computed from data of Textile Economics Bureau and U.S. Department of Commerce with use of U.S. Department of Agriculture factors for conversion to equivalent cotton bales. Estimates for 1966 assume fourth quarter to be at same level as third quarter.

3. Cotton as an agricultural commodity has problems and opportunities similar to those of many other crop and livestock products in farm and farm-related research. The control of pests and diseases, further mechanization and automation, and the general improvement of the plant and its culture offer substantial potentials for greater efficiency and lower costs.

Unlike most other agricultural products, however, cotton goes into end uses in which the competition is almost exclusively with industrial materials, all of which are the man-made products of science and all of which receive enormous continuing research directed toward lower costs and improvement of specific end products. Not only does the nature of this competition place a ceiling at which cotton may be effectively priced, but also a special urgency in reducing the present costs of producing cotton.

The greatest impact of the special competition which cotton faces, however, is in the end-use markets for textile products. It is here that individual and industrial consumers choose their textile products, largely on the basis of performance, promotion, and price. And it is here that the greatest proportion of the synthetic fiber research effort--now estimated at over \$149,000,000 annually--is concentrated.

It is perfectly clear to anyone at all familiar with the textile industry that cotton cannot hope to maintain anything like its present share of the U. S. and foreign markets for fiber products, if the present disparity in research and promotional effort is not somehow narrowed very considerably. The estimated gap is now roughly \$1,251,000,000 in research and \$651,000 in sales promotion and advertising.

This situation has been carefully considered in formulating the research recommendations which are set forth in this report. A very substantial expansion in quality improvement and product development research obviously must be carried out if any research on cotton is to make sense. The magnitude of this effort has been carefully assessed, based on the known research by cotton's competitors and the known problems and opportunities of cotton itself. The fact that the research program which cotton must have may appear out of balance with that required by other agricultural commodities is entirely incidental. The Cotton Task Force believes that the nature of cotton's special competitive situation and its consequent demand for an extraordinary research effort in the utilization area must be set forth clearly and bluntly.

Whether or not the Federal-State research establishment can, or should, provide all or most of the heavy burden of product development research which cotton must have to remain competitive is a question which this report does not attempt to answer. The report simply points out what is needed. Cotton must certainly also have a great deal more promotional support. Cotton farmers themselves have moved to provide a substantial step-up in support for both research and promotion. They themselves must decide whether they can, and will, do still more in the future. This report simply states the magnitude of the research need, regardless of the origin of the support, whether Federal, State, or from private sources.

Economic Impact of Cotton's Situation

The general welfare of the entire Cotton Belt--19 States from Carolina to California--depends heavily on cotton. The economic dislocations resulting from growing, processing, and handling 9 to 10 million bales a year instead of a more normal 14 or 15 million are serious; without Government aid, they would be disastrous.

The situation has wider implications. Raw cotton exports earn an average of \$412 million a year, a vital contribution to the U. S. balance of payments position. To protect this contribution--and enlarge it--requires a strong, competitive, expanding cotton industry.

Cotton's Needs in Research

The market for textile fibers differs little from that for most other products; sales depend on three key factors: price, performance, and promotion. Two of these factors--price and performance--respond, or may respond, directly to research.

Stated in broad terms, cotton needs research in three areas:

1. To cut costs and losses and increase efficiency in producing and processing cotton.

Cotton farmers must be able to meet direct price competition from both rayon and foreign-grown cotton. Research has the potential of reducing costs and losses in producing, handling, and processing cotton on the average at current prices, by approximately 10 cents per pound.

2. To improve, preserve, and deliver quality in cotton.

The new technologies of mechanical harvesting and more elaborate ginning have changed the appearance of cotton so that assessment of quality by grade and staple alone is no longer adequate. Textile mills have also greatly increased their own productivity with automation and higher speeds which demand predictable and dependable fiber performance. Commercial methods for precisely measuring the physical properties of raw cotton are urgently needed to assure mill satisfaction. Methods are also needed to provide objectives and incentives for quality improvement through agronomic research, and more effective guides for preservation of quality in harvesting and ginning.

3. To develop new and improved cotton products.

New products and new performance qualities are the fundamental basis of synthetic fiber competition with cotton. Greater strength, added wear-life, quick drying, durable shape retention, stretch, low bulk, ventilation, insulation, and other qualities have been built into synthetic and blended products. These characteristics have been heavily promoted to consumers by the man-made fiber manufacturers. Cotton must also provide many of these properties if its markets are to be held or expanded.

4. To facilitate adjustments of people, businesses, and communities.

Findings that contribute to means of cutting costs; reducing losses; increasing efficiency; improving, preserving, and delivering quality; and developing new and improved products all have strong structural and locational implications. The per unit cost of improved farm machinery, for example, is such that its most economical and most efficient use is in association with an economic sized production unit. Size and topography of fields lead to the choice of areas on which equipment may be most effectively utilized. Some areas also yield greater proportional returns than others to added inputs of farm machinery and other improved technology and management. Producing and processing areas change with attention to these factors.

As improved technology is applied and as the amount of product needed may be produced with less people and with different and probably less acres, people involved in former processes, locations, and enterprises must change jobs and perhaps relocate. Some are unable or unwilling to do. Communities change accordingly.

Undoubtedly, net accruals to the benefit of society are possible and probable as a result of the workings of this process of economic development. An improved capability to predict its workings and to soften its impact on the peoples and areas displaced is desirable and worthy of considerable research effort. Such research would fall within the following RPA's: 802, 803, 804, 805, 806, 807, 808, 907, and 908. These areas fall within the purview of the farm prices and income analysis, and rural development task forces. The Cotton Task Force calls attention to their importance here, recommends careful attention to them by those task forces, and suggests the reader refer to the reports of those task forces for further information.

Opportunities for Cotton Research

This study has sought to isolate and describe key opportunities for cotton research and to translate them into precise lines of work in several problem areas.

The opportunities are wide and so are the resources to exploit them. Both the USDA and the State experiment stations of the Cotton Belt now carry out extensive programs of research on most aspects of cotton production and processing. Mills, finishers, chemical manufacturers, farm equipment firms, and other elements of private industry now contribute to the total cotton research effort and could do still more with cooperative support. Cotton producers themselves have stepped up their fund contributions and fertile ideas through their own research and promotion organization.

The basic research machinery needed to work for cotton is in place. It includes scientists, equipment, and laboratories, through the facilities of the State experiment stations, the USDA, and scores of private research institutes and organizations. But the present magnitude of the program and the shop is inadequate to the total job of research that must be done.

Cotton's Research Difficulties

The diversity of cotton's research resources is, in some ways, disadvantageous. In contrast to the concentrated, closely coordinated, thoroughly integrated research programs of the synthetic fiber industry, cotton research is scattered and divided among dozens of agencies and scores of laboratories from coast to coast. There are even bits and pieces overseas under the PL-480 program. This very diversity has the value at times, however, of more original thought and initiative on the part of the researchers.

Much of cotton's program is carried out by competent, dedicated scientists, but in few cases is their research supported by enough technical assistants to give their efforts the depth which is desirable for rapid progress.

Cotton's Special Advantages

Cotton has three very major advantages relative to synthetic fibers which strongly support the contention that it can remain competitive with the man-made fibers far into the future.

1. Economy.

Cotton can be produced for sale at prices which are among the lowest for any major fiber. If sufficient research support can be applied to increasing efficiencies in cotton production and marketing, it should be possible to regain and maintain a favorable price position for cotton.

2. Inherent properties.

Cotton inherently possesses a better balance of desired properties in the broad spectrum of textile uses than can be found in any other fiber, natural or man-made. In addition, the form and properties of cotton fit almost ideally the processing requirements of textile spinning and weaving mills.

3. Chemical reactivity.

Cotton's chemical reactivity, which permits the fiber to serve as the base for many new, specialized characteristics, may well be its strongest asset.

Cottonseed and Cottonseed Products

Cottonseed is an important component of the cotton crop. Cotton planting seed is a commodity in itself, differentiated from seed as a raw product for processing purposes. Planting seed is grown and merchandized in the main by pedigreed seed farms and corporations. High-grade planting seed is indispensable to the growing of a high quality crop of cotton. The growing, handling, and merchandizing of planting seed is a highly specialized business. It is beset by all the production problems that confront the grower of commercial cotton, plus many special difficulties of plant breeding to meet specifications that are required in the commercial crop.

Cottonseed for processing purposes likewise must be of a quality to produce desirable manufactured products, at a raw commodity price that will compete successfully with other resource materials. Much of the research appropriate for growing, harvesting, and ginning of the fiber is fully applicable to the efficient production of high quality seed for processing.

Research on the handling and processing of cottonseed subsequent to ginning is needed to reduce costs and improve the end products. New and improved edible and industrial use products from cottonseed offer enlarged potential, through research and development.

Benefits of Cotton Research

The benefits of cotton research will not accrue exclusively to cotton.

Government expenditures can be reduced by very substantial amounts for each 1 cent-per-pound cut in production costs, with no lessening in producer income.

The textile industry can be assured an adequate supply of its Number One raw material under competitive conditions.

Consumers can continue to have their choice, at reasonable prices, of a full range of products made of the fiber they prefer for comfort and convenience.

If the concerned agencies, groups, and firms are able to provide for stepped-up research on cotton, there is every reason to believe that cotton's unique balance of desirable inherent properties, the possibilities for its low-cost production, and its adaptability to new qualities through chemical finishing will keep it among the strongest competitors in the textile market.

SUMMARY

Research Opportunities

Research Problem Area 207 - Control of Insect Pests of Field Crops

Research programs in Federal, State, and industry centers must actively seek greater sophistication in the development of new and more efficient techniques including improved chemicals for ultimate utilization in insect control on cotton.

There is increasing evidence that in some instances cotton insect problems under modern agricultural practices are becoming more acute. In other instances, present practices tend to reduce the severity of certain insects and the factors involved become complex and difficult to evaluate.

High levels of insecticide resistance have developed in most of the serious cotton pests. Attempts to cope with the resistance problem have often resulted in more frequent insecticide applications; often these are with short-lived, broad-spectrum materials. If current practices continue, there is reason to believe the situation will worsen. There is increasing concern over the use of persistent insecticides because of their adverse effect on other environmental problems. Other control measures are being sought.

It has become clearly evident that insect control to the maximum extent possible should be an exercise in applied ecology. The ultimate goal should be the development of integrated control programs variously designed for the different environmental conditions and pest complexes across the Cotton Belt. The purview of integrated control is broad and includes the utilization of all pest control techniques in a compatible manner so that the use of one does not disrupt another, but rather supplements or achieves better results than any one method employed alone. Research directed toward the implementation of integrated control programs must be expanded immediately and significantly if control costs and losses to insects are to be reduced in the coming years.

As with many crops, cotton is attacked by several consistently damaging pests which dominate control practices and for which current methods of control are inimical to the development of integrated control. These are "key" pests in cotton production and are generally considered to be the boll weevil, bollworms, pink bollworm, and lygus bugs. If methods for controlling these pests can be developed which are not disruptive to the ecosystem, it is believed that certain other cotton pest problems will be reduced or even negated.

New techniques of insect control, such as the sterile insect release method, and possibly sex pheromones, when properly integrated with other control methods, offer excellent possibilities for continuous suppression of population of key species or even eradication by selective means. Research to develop and demonstrate such techniques must be carried out on large or well isolated populations that require substantial research resources.

Specific research units proposed under RPA 207:

- A. Boll weevil control or eradication.
- B. Bollworm control.
- C. Pink bollworm control or eradication.
- D. Lygus bug control.
- E. Spider mite, cotton fleahopper, cotton aphid, and other cotton pest controls.
- F. Methods and equipment for insect control.

Research Problem Area 208 - Control of Diseases of Field Crops

Diseases of cotton contribute to both indirect and direct costs connected with production and processing. Indirect costs involve the overall inefficiency of the cotton plant and include inefficiencies in cultural practices, limitations in land use, water loss, alterations of the environment through control efforts, etc., which are not so subtle but are difficult to compute. Whatever the indirect costs, it is doubtful that the results of estimation procedures that might be used to detail such costs would contribute to the research system evaluation process. It is probably sufficient for this purpose to recognize that the goals of disease research are such as to be inherently inclusive of the need to reduce these indirect effects of disease on the production and utilization of cotton.

Direct costs of diseases of cotton are more readily estimated, and include such functions as yield loss and reduction, growth impact, cost of control measures, reduction in quality of fiber and seed, etc. The estimates of these direct costs attributable to disease have been represented collectively as approximately 28 percent of costs incurred in the production of cotton. (No estimate of the cost of disease in the utilization of cotton and cottonseed is available.) The research system designed herein is proposed in part to reduce these losses to the cotton industry.

Specific research units proposed under RPA 208:

- A. Diseases caused by pathogenic organisms (Etiology).
- B. Diseases caused by pathogenic organisms (Epidemiology).
- C. Diseases caused by pathogenic organisms (Ecology).
- D. Response of the cotton plant to pathogenic organisms.
- E. Indirect methods of reducing disease losses.
- F. Disease control through resistant varieties.
- G. Control--biocides, fates.
- H. Microbial interactions.
- I. Disease vectors.
- J. Toxins--bacterial, fungal, nemal.
- K. Disease interactions--growth regulators and biocides.
- L. Diseases of weeds.

Research Problem Area 209 - Control of Weeds and Other Hazards of
Field Crops

A wide variety of annual and perennial grasses, sedges, and broad-leaf weeds constitute major production problems in cotton. Herbicides have been used extensively in recent years to control weeds but lack of adequate herbicides specific for the control of major problem weeds has resulted in invasion of thousands of acres of the more productive cotton land by johnsongrass, nutsedge, and annual and perennial broadleaf weeds. Losses result from (a) direct losses due to weeds, (b) reductions in fiber quality, mechanical harvesting, and ginning efficiency, and (c) increased labor requirements in all phases of cotton production because of the presence of weeds.

Specific research units proposed under RPA 209:

- A. Johnsongrass control or eradication.
- B. Nutsedge control or eradication.
- C. Sida control.

- D. Cocklebur control or eradication.
- E. Annual grasses and sedges control.
- F. Annual broadleaf weeds control.
- G. Bermudagrass control.
- H. Perennial broadleaf weeds control or eradication.
- I. Winter weeds control or eradication.
- J. Biological control of individual weed species.
- K. Problems created by weed control measures.
- L. Interactions of herbicides with insecticides, fungicides, nematocides, defoliants, fertilizers, and tailoring agents.
- M. Methods and equipment for weed control.

Research Problem Area 307 - Improvement of Biological Efficiency of
Field Crops

In the past 25 years, great progress has been made in the development of cotton varieties fairly well adapted to mechanical production and machine harvesting. Even so, current production efficiencies are far from adequate. Pressures for further improvements in raw fiber properties will undoubtedly be accelerated in the future. Therefore, the continuing demand will be for the longer fiber cotton having greater tensile strength, uniformity of fiber length, and fineness in those combinations required by the mills, which will at the same time have high yielding capacities and which are adapted to varying environmental conditions. These changes will result in optimum yields of the quality fiber that will make cotton highly competitive with man-made fibers and at the same time give the producer proper returns for his efforts.

Specific research units proposed under RPA 307:

- A. Improved combinations of yield and high quality fiber components.
- B. Improved cultural practices.
- C. Improved pest resistance.

- D. Improved harvesting characteristics.
- E. Improved cottonseed quality.

Research Problem Area 308 - Mechanization of Production of Field Crops

A thorough analysis of all the cotton production phases indicates that few areas stand out for reducing costs more than the inefficient handling and pre-ginning storage methods now in use. Harvesters spend a large portion of their potential operating time dumping loads into transport units that require extra labor at the turnrow for this operation. Further, field conveyances, such as trailers, make high-priced storage units, take up valuable space on gin yards, and require extra men and power units for placing them where they can be unloaded when the gin is ready to receive the seed cotton.

Although much of the cotton ginning equipment has been automated, a surplus of manpower is still in evidence. Contributing to ginning costs is the large amount of trash that must be handled with present harvesting systems. Much more stringent regulations dealing with the disposal of trash and the control of dust and "fly" are being enacted by the Federal Government, States, and municipalities.

The inefficient system for packaging and sampling is a chapter in tradition that can only be resolved by progressive minded industry with the conscientious objective of preserving a place for cotton fiber in the lives of people and industry of tomorrow. Some of the equipment and methods for improving the situation are presently available; however, little interest in further developments can be expected until the demands of the industry change.

Great strides have been made in the design of machinery for cotton production and ginning, but continued pressure must be exerted toward the development of more efficient methods and equipment to reduce losses, better utilize available labor, and preserve the inherent quality of the fiber.

Specific research units proposed under RPA 308 (mechanization of production):

- A. Planting, fertilizing, and tillage.
- B. Pest control--weeds, insects, and diseases.
- C. Harvesting.
- D. Handling, transportation, and storage.

E. Ginning.

F. Crop-climate relationships.

Research Problem Area 309 - Systems Analysis in Production of Field Crops

The need for increased production efficiency and thereby lowered production costs in cotton is quite evident. Increased efficiency and lower costs would improve cotton's competitive position both at home and abroad. During recent years, the expansion of production in man-made fibers and increases in the production of foreign growths of cotton have made serious inroads in the use of U.S. cotton.

Research approaches to this problem can be made in a number of ways, all of which are more or less interrelated.

Specific research units proposed under RPA 309:

- A. Evaluations of emerging technology.
- B. Labor efficiency.
- C. Regional analysis of cost of production.
- D. Adjustments in cotton production.
- E. Machine systems (systems analysis for optimum return).

Research Problem Area 405 - Production of Fields Crops With
Improved Consumer Acceptability

Much of the cotton now produced in the U. S. does not have fiber properties that adequately meet modern textile mill requirements. Knowledge of the factors affecting fiber quality is needed to improve, as well as to preserve, the characteristics for consumer acceptability from the processors' and ultimate consumers' points of view.

Specific research units proposed under RPA 405:

- A. Production of cotton with improved fiber properties for greater consumer acceptability.
- B. Quality preservation during the harvesting and ginning operations (production for improved consumer acceptability).

Research Problem Area 406 - New and Improved Food Products from Field Crops

The competitive position of cottonseed oil has been challenged over the last two decades. For many years, cottonseed ranked first in importance as a source of vegetable fats and oils, in terms of both the quantity consumed annually and the quality of its products. This preeminent position of cottonseed oil has gradually declined because of the improved quality of competitive products and their availability at substantially lower prices.

Growing world needs for high quality sources of protein opens up new usage areas to cottonseed food products, and imposes the obligation to develop sources of high quality protein from this important oilseed.

Specific research units proposed under RPA 406:

A. Better cottonseed food products.

Research Problem Area 407 - New and Improved Feed, Textile, and Industrial Products from Field Crops

Cotton's century and a half of use as the principal textile fiber has led to a high degree of efficiency in both processing methods and equipment. In fact, the "cotton system" has become the basis for almost all textile manufacturing operations. It is perhaps understandable that it is not a simple matter to devise entirely new processing methods and equipment for cotton. Most of the innovations during the past quarter century have been adaptations or modifications of existing systems and equipment.

In general, the prospects for reducing the costs of cotton products are not as promising, in the absolute sense, at the mill processing stage as in the production of the fiber itself. The opportunities that are significant at the processing level are mainly those which overcome cotton's disadvantages relative to synthetics, or which may give cotton some special advantage. Thus, research directed toward more efficient and more effective removal of waste from cotton would improve cotton's position relative to the waste-free synthetic staples. On the other hand, research on weaving could be expected to benefit synthetics almost as much as cotton, and from the cotton viewpoint that type of research would command a relatively low priority. The important areas of mill processing research on cotton would therefore be, in addition to better waste control, studies directed toward overcoming the non-uniformity of staple lengths in cotton and their effects on processing performance and yarn quality, and to compensating for the variabilities in other properties which are inherent in an agricultural raw material.

The magnitude of the effort required to develop, improve, and commercialize more competitive cotton products should not be underestimated. This type of research is expensive. It takes time and it never ends. So long as the synthetic fiber manufacturers continue their huge expenditures for research and development, cotton's position in any and all of its markets will be constantly imperiled. Only a continuing effort to upgrade each product line, to match any characteristics offered by competitors, and to provide adequate promotional support for cotton products will enable these markets to be held.

The present state of seed crushing technology owes much to past research and development activities in this area. There is, however, need for additional research to improve processing efficiency and to afford higher quality oil and meal products of greater utility.

Specific research units proposed under RPA 407:

- A. Textile production efficiency.
- B. Higher manufacturing quality.
- C. Improved finishing efficiency.
- D. Durable press, warmth, and other resilience properties.
- E. Fire-, weather-, water-resistance and other chemical properties.
- F. Luster, smoothness, and other surface properties.
- G. Strength, low-bulk, sheerness, and related properties.
- H. Abrasion and linting resistance, and related properties.
- I. Improved clothing products.
- J. Better household products.
- K. More competitive industrial products.
- L. More efficient cottonseed processing.
- M. New and improved feed and industrial products from cottonseed.

Research Problem Area 408 - Quality Maintenance in Marketing Field Crops

Serious losses in end-use quality that occur as a result of physical and chemical changes in transportation and storage of cotton and cottonseed products suggest investigations to determine proper packing techniques, optimum storage conditions, most favorable temperature, moisture or atmosphere control, and correct handling procedures. Under improper storage conditions, there may be a change in the color of cotton lint or changes in other fiber properties which affect ultimate utilization. Similarly, cottonseed, cottonseed oil, and cottonseed meal may deteriorate in quality from the standpoint of food and feed uses.

Specific research units proposed under RPA 408:

- A. Measurement of factors affecting cotton quality.
- B. Improved techniques and equipment for handling and storing baled cotton in warehouses.
- C. Improved techniques and equipment for long-term storage of baled cotton.
- D. Improved techniques and equipment for handling, drying, and storing cottonseed.

Research Problem Area 501 - Improvement of Grades and Standards

Visual grades and standards for cotton are not as useful as they could be for determining value because they do not adequately cover characteristics desired by users. Present methods of determining the characteristics and value could be improved by the augmentation or substitution of instrument measurements.

Specific research units proposed under RPA 501:

- A. Measuring quality factors and value of cotton.
- B. Measurement of factors affecting cottonseed quality.

Research Problem Area 504 - Physical and Economic Efficiency in Marketing
Field Crops

Improving physical and economic efficiency in marketing field crops is of critical importance in maintaining the rapidly rising levels of living in the United States. It will also help to prevent a further decline in the farmer's share of consumer expenditures. Rising costs of labor and other inputs and increasing demand by consumers for added services tend to increase marketing costs, and frequently restrict the farmer's market. Research on improved physical and economic efficiency in marketing and processing will help to offset these forces.

Specific research units proposed under RPA 504:

A. Firm efficiency and marketing costs for cotton.

TABLE 2.--Cotton and cottonseed research requirements to attain LRS projection

RPA No.	1966 (SMY)	1968 (SMY)	1969 (SMY)	1970 (SMY)	1971 (SMY)	1972 (SMY)	1977 (SMY)	1966-77 Increase		Incr. per yr. (SMY)
								USDA (SMY)	SAES (SMY)	
207	91.1	92.7	94.3	95.9	97.5	99.1	107.1*	10	6	1.60
208	47.6	49.8	52.0	54.2	56.4	58.6	69.6*	11	11	2.20
209	22.2	22.4	22.6	22.8	23.0	23.2	24.2	1	1	.20
307	98.8	107.4	116.0	124.6	133.2	141.8	184.8	17	69	8.60
308	38.6	39.2	39.8	40.4	41.0	41.6	44.6	4	2	.60
309	2.2	2.6	3.0	3.4	3.8	4.2	6.2	0	4	.40
405	14.6	17.0	19.4	21.8	24.2	26.6	38.6	15	9	2.40
406	25.9	25.9	25.9	25.9	25.9	25.9	25.9	0	0	.00
407	145.2	147.7	150.2	152.7	155.2	157.7	170.2*	24	1	2.50
408	10.6	11.1	11.6	12.1	12.6	13.1	15.6*	3	2	.50
501	3.2	3.6	4.0	4.4	4.8	5.2	7.2*	4	0	.40
504	15.4	15.7	16.0	16.3	16.6	16.9	18.4*	3	0	.30
Total	515.4	535.1	554.8	574.5	594.2	613.9	712.4	92.0	105	19.70
Per SMY**	\$38,000	\$42,700	\$45,260	\$48,000	\$50,880	\$53,930				
Total (000)	\$19,585	\$22,849	\$25,110	\$27,576	\$30,233	\$33,108				

*Adjusted by ARPC Joint Task Force - Chicago meeting, July 21-22, 1967.

**Allows 6 percent per year increase to maintain preceding year level of program.

TABLE 3.--Comparison of the LRS and the Cotton and Cottonseed
Task Force recommendations

Research Problem Area	Agency	Fiscal Year			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
207. Control of insect pests of field crops					
Task Force recommendation	USDA	59.6	87.6	113.6	128.6
	SAES	32.1	73.5	95.5	101.5
	Total	91.7	161.1	209.1	230.1
<u>LRS Total</u>					107.1
Difference					123.0
208. Control of diseases of field crops					
Task Force recommendation	USDA	22.9	27.7	33.4	40.2
	SAES	24.7	42.6	57.8	72.2
	Total	47.6	70.3	91.2	112.4
<u>LRS Total</u>					69.6
Difference					42.8
209. Control of weeds and other hazards of field crops					
Task Force recommendation	USDA	5.5	24.5	39.0	28.5
	SAES	16.7	41.0	65.0	33.5
	Total	22.2	65.5	104.0	62.0
<u>LRS Total</u>					24.2
Difference					37.8
307. Improvement of biological efficiency of field crops					
Task Force recommendation	USDA	25.7	64.0	79.0	94.0
	SAES	73.1	104.7	138.7	177.7
	Total	98.8	168.7	217.7	271.7
<u>LRS Total</u>					184.8
Difference					86.9

(continued)

TABLE 3.--Comparison of the LRS and the Cotton and Cottonseed Task Force recommendations (continued)

<u>Research Problem Area</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
308. Mechanization of production of field crops					
Task Force recommendation	USDA	19.4	31.0	40.0	56.0
	SAES	19.2	31.0	41.0	56.0
	Total	38.6	62.0	81.0	112.0
LRS Total					44.6
Difference					67.4
309. Systems analysis in produc- tion of field crops					
Task Force recommendation	USDA	0	23.0	31.0	33.0
	SAES	2.2	19.0	22.0	24.0
	Total	2.2	42.0	53.0	57.0
LRS Total					6.2
Difference					50.8
405. Production of field crops with improved consumer acceptability					
Task Force recommendation	USDA	9.3	14.0	20.0	28.0
	SAES	5.3	8.0	11.0	16.0
	Total	14.6	22.0	31.0	44.0
LRS Total					38.6
Difference					5.4
406. New and improved food pro- ducts from field crops					
Task Force recommendation	USDA	25.7	22.0	26.0	30.0
	SAES	0.2	2.0	3.0	4.0
	Total	25.9	24.0	29.0	34.0
LRS Total					25.9
Difference					8.1

(continued)

TABLE 3.--Comparison of the LRS and the Cotton and Cottonseed
Task Force recommendations (continued)

Research Problem Area	Agency	Fiscal Year			
		1966 (SMY)	1969 (SMY)	1972 (SMY)	1977 (SMY)
407. New and improved feed, textile, and industrial products from field crops					
Task Force recommendation	USDA	139.4	196.0	352.0	530.0
	SAES	5.8	26.0	48.0	79.0
	Total	145.2	222.0	400.0	609.0
LRS Total					170.2
Difference					438.8
408. Quality maintenance in marketing field crops					
Task Force recommendation	USDA	8.6	19.0	20.0	30.0
	SAES	2.0	5.0	5.0	9.0
	Total	10.6	24.0	25.0	39.0
LRS Total					15.6
Difference					23.4
501. Improvement of grades and standards					
Task Force recommendation	USDA	2.3	20.0	25.0	31.0
	SAES	0.9	3.0	4.0	4.0
	Total	3.2	23.0	29.0	35.0
LRS Total					7.2
Difference					27.8
504. Physical and economic efficiency in marketing field crops					
Task Force recommendation	USDA	13.0	14.0	16.0	21.0
	SAES	2.4	3.0	6.0	12.0
	Total	15.4	17.0	22.0	33.0
LRS Total					18.4
Difference					14.6
Task Force recommendation Total		516.0	901.6	1292.0	1639.2
LRS Total					712.4
Total Difference					926.8

TABLE 4.--Scientific man-year research requirements estimated by the Cotton and Cottonseed Task Force

<u>Research Problem Area</u>	<u>Fiscal Year</u>			
	<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
207. Control of insect pests of field crops	91.7	161.1	209.1	230.1
208. Control of diseases of field crops	47.6	70.3	91.2	112.4
209. Control of weeds and other hazards of field crops	22.2	65.5	104.0	62.0
307. Improvement of biological efficiency of field crops	98.8	168.7	217.7	271.7
308. Mechanization of production of field crops	38.6	62.0	81.0	112.0
309. Systems analysis in production of field crops	2.2	42.0	53.0	57.0
405. Production of field crops with improved consumer acceptability	14.6	22.0	31.0	44.0
406. New and improved food products from field crops	25.9	24.0	29.0	34.0
407. New and improved feed, textile, and industrial products from field crops	145.2	222.0	400.0	609.0
408. Quality maintenance in marketing field crops	10.6	24.0	25.0	39.0
501. Improvement of grades and standards	3.2	23.0	29.0	35.0
504. Physical and economic efficiency in marketing field crops	15.4	17.0	22.0	33.0
Total	516.0*	901.6	1292.0	1639.2

*The Cotton and Cottonseed Task Force could not reconcile the 1966 SMY figures with the official research inventory for 1966 of 515.4.

TABLE 5.--Research facility needs estimated by the
Cotton and Cottonseed Task Force

<u>Research Problem Area</u>	<u>Cost Estimates</u> (Thousand dollars)
207. Control of insect pests of field crops	\$ 7,200
208. Control of diseases of field crops	3,000
209. Control of weeds and other hazards of field crops	4,000
307. Improvement of biological efficiency of field crops	3,225
308. Mechanization of production of field crops	4,404
309. Systems analysis in production of field crops	330
405. Production of field crops with improved consumer acceptability	900
406. New and improved food products from field crops	100
407. New and improved feed, textile, and industrial products from field crops	12,600
408. Quality maintenance in marketing field crops	3,031
501. Improvement of grades and standards	192
504. Physical and economic efficiency in marketing field crops	108
	<hr/>
Total	\$39,090

TABLE 6.--Cotton and cottonseed research program projections
and potential source of support

<u>Year</u>	<u>LRS Projected*</u>			<u>Special cost cutting (SMY)</u>	<u>Cotton Pr. Inst. (SMY)</u>	<u>Unallocated (SMY)</u>	<u>Total program (SMY)</u>
	<u>USDA (SMY)</u>	<u>SAES (SMY)</u>	<u>TOTAL (SMY)</u>				
1966	329.2	186.2	515.4	--	--	--	515.4
1968	331.8	203.3	535.1	174.5	63.2	--	772.8
1969	332.9	221.9	554.8	220.9	99.4	26.5	901.6
1970	344.7	229.8	574.5	208.3	104.2	144.7	1031.7
1971	356.5	237.7	594.2	196.5	98.3	272.9	1161.9
1972	368.3	245.6	613.9	185.4	92.7	400.0	1292.0
1977	455.9	256.5	712.4	--	--	--	1639.2

* Divided between USDA and SAES as Task Force divided total program for years 1969, 1972, and 1977.

TABLE 7.--Potential fund support for
Cotton and Cottonseed Research Program

<u>Year</u>	<u>LRS Projected</u>			<u>Special cost cutting</u>	<u>Cotton Pr. Inst.</u>	<u>Unallocated</u>	<u>Total program</u>
	<u>USDA</u>	<u>SAES</u>	<u>TOTAL</u>				
	1,000	1,000	1,000	1,000	1,000	1,000	1,000
	dol.	dol.	dol.	dol.	dol.	dol.	dol.
1966	12,510	7,075	19,585	--	--	--	19,585
1968	14,168	8,681	22,849	7,450	2,700	--	32,999
1969	15,067	10,043	25,110	10,000	4,500	1,196	40,806
1970	16,546	11,030	27,576	10,000	5,000	6,946	49,522
1971	18,139	12,094	30,233	10,000	5,000	13,884	59,117
1972	19,863	13,245	33,108	10,000	5,000	21,570	69,678

RESEARCH OPPORTUNITIES

Research Problem Area 207 - Control of Insect Pests of Field Crops

Situation

Insect pest control on cotton is one of the important factors in efficient cotton production despite continuing and sometimes dramatic advances in entomological research and pesticide technology. Without pest control, the contributions of other scientific disciplines to improved cotton production may be partially or wholly lost. With current pest control practices, the potential losses due to insects are largely avoided, but still annual losses are variously estimated to be as high as 10 to 20 percent of current production. Farmer expenditures for insecticides and fungicides were 3.2 percent of the total cost of cotton production in 1964. In most cases control measures rely heavily upon insecticides for success; undoubtedly, this will remain as the primary means of defense for most pest problems in the foreseeable future. As current control measures are costly and pest losses remain significant, these practices are certainly less than ideal. Thus, research programs in Federal, State, and industry centers must actively seek greater sophistication in the development of new and more efficient techniques including improved chemicals for ultimate utilization in insect control on cotton.

There is increasing evidence that cotton insect problems under modern agricultural practices are becoming more acute in some instances. In other instances, present practices tend to reduce the severity of certain insects. The factors involved become complex and difficult to evaluate. However, increased irrigation and higher rates of fertilization cause crops to be less determinate and give opportunity for at least one additional generation annually of the boll weevil and several other cotton pests including the pink bollworm and the bollworm to be produced. On the other hand, in other areas, mechanical harvesting, plus the procedures involved in preparing for harvest, reduces boll weevil and pink bollworm populations entering winter diapause. Also the clearing of virgin lands and clean cultivation are reducing favorable overwintering sites for some insects such as the boll weevil in some areas. At the same time such practices may also reduce the survival rate of predators and parasites. New major crops such as soybeans and new forage crops provide new host plants for the bollworm complex. The impact of these changes on bollworm and other cotton insects is not known. A more diversified agriculture may increase the importance of lygus bugs, another multi-host insect.

High levels of resistance to some insecticides have developed in most of the serious pests. Attempts to cope with the resistance problem have often resulted in more frequent insecticide applications; often, these are with short-lived, broad-spectrum materials. Thus, production costs have spiraled and secondary pest problems have been triggered to such a point that efficient insect control is now in jeopardy in some areas of the Cotton Belt. If current practices continue, there is reason to believe the situation will worsen. There is increasing concern over the use of persistent insecticides. Other control measures are being sought. The substitution of persistent residue-accumulating insecticides with non-persistent broad spectrum insecticides may lessen the residue problem in the environment and in certain crops grown in rotation with cotton. However, the alternate materials now available could cause more harm to insect parasites, insect predators, and pollinating insects because of their high toxicity to insects in general and because more frequent applications may be necessary for controlling the target pest.

It has become clearly evident that insect control to the maximum extent possible should be an exercise in applied ecology. The ultimate goal should be the development of integrated control programs variously designed for the different environmental conditions and pest complexes across the Cotton Belt. The purview of integrated control is broad and includes the utilization of all pest control techniques in a compatible manner so that the use of one does not disrupt another, but rather supplements or achieves better results than any one method employed alone. By definition, control methods such as chemical, cultural, biological, plant resistance, sterile male techniques, and others are all included. As one example, cotton fields, undisturbed by insecticide application, contain varying populations of many beneficial predator and parasite species. Such beneficial insects often regulate populations of certain pest species below economic thresholds. When a pest species reaches a population level necessitating insecticide applications, it often follows that beneficial insect populations are reduced to a low level, thereby releasing other species from their biological checks.

As with many crops, cotton is attacked by several consistently damaging pests which dominate control practices and for which current methods of control are inimical to the development of integrated control. These are "key" pests in cotton production and are generally considered to be the boll weevil, bollworms, pink bollworm, and lygus bugs. If methods of controlling these pests can be developed which are not disruptive to the ecosystem, it is believed that certain other cotton pest problems will be reduced or even negated. Even the selective control of one or more of the key pests could contribute to control of another.

For example, selective control or elimination of the boll weevil would permit the many natural enemies of the bollworms to exert their maximum effect. Thus, in appraising the needs for controlling cotton insects, it is important to take a look at the total problem and take into account the impact that control methods for one species might have on another. Many of the less serious pests can be controlled with insecticides which are at least somewhat selective, if application should become necessary. For these reasons, this section of the report deals largely with the above listed key pests.

The research projections in this report do not include special research support that would be essential if research in any areas, such as on the boll weevil and the pink bollworm, progresses to the point of major action programs to eradicate the insects from specified areas.

Specific Research Units, RPA 207

A. Boll weevil control or eradication.

1. Situation: The boll weevil is the most costly insect pest of cotton, causing estimated losses in yield of approximately 8 percent plus extensive control costs. In addition, insecticides, which provide the only generally practical means of control, destroy natural enemies of such insects as the bollworms, mites, and aphids which lead to further losses and costs of control. Moreover, the insecticides used for boll weevil control create residue problems and contaminate the environment to the extent that fish and wildlife resources are subjected to their hazards. Research is underway on every feasible means of control, including ways that hopefully can be employed to eradicate this key insect or at least to relegate it to a minor factor in cotton production efficiency. Substantial progress has been made in various areas that need to be fully investigated to develop their potential for achieving more economical control or that might be integrated for eventual eradication.

2. Objective: Develop procedures for the eradication of the boll weevil, or at least develop effective economical and selective methods of control that will reduce boll weevil populations below economic levels, thus substantially lowering costs of cotton production and at the same time make a major contribution to a reduction in environmental pollution due to insecticides.

3. Research approaches:

- a. Extend biological and ecological information pertaining to methods of control or eradication in different boll weevil areas.

- b. Determine the effectiveness, selectivity, and safety of new insecticides, including systemics, and how they can be used in integrated programs designed for the control or eradication of boll weevil populations. Particular attention should be given to chemicals with novel structures as new modes of toxicity are vitally needed.
- c. Obtain information on all kinds of natural biological agents that affect boll weevils and determine their potential usefulness in suppressing boll weevil populations.
- d. Find suitable ways to sterilize boll weevils and develop mass rearing, mass handling, and field release procedures for the elimination of low-level populations.
- e. To cooperate with plant breeders in search for boll weevil-resistant germ plasm and incorporate such resistance into acceptable varieties that can be grown without extra cost to growers and which will eliminate losses due to the boll weevil.
- f. Determine for different areas how cultural practices can be used to reduce boll weevil populations (particularly overwintering forms) and how such practices can best supplement control or eradication procedures.
- g. Obtain information on boll weevil physiology, basic metabolism of chemicals employed for control and develop basic information on nutritional requirements that will facilitate mass rearing of vigorous and competitive boll weevils for use in the sterile male technique.
- h. Investigate the possibility of using sex lures or other forms of attractants derived from the cotton plant in an integrated control program.

4. Character of potential benefits: Eliminate or substantially reduce losses in yield and costs for boll weevil control; correct environmental pollution caused by insecticides now used for boll weevil control which cause residue problems in agricultural products, create hazards to fish and wildlife, and adversely affect insect parasites, insect predators, and pollinating insects.

B. Bollworm control.

1. Situation: Two species of bollworms attack cotton throughout the cotton-growing areas (except in the Western States where only one is serious). These insects cause losses to cotton production efficiency that are estimated to average about 4 percent annually. The insects also attack other major agricultural crops. The wide host plant range and the diversified ecological situations that exist in cotton-growing areas add greatly to the complexity of the bollworm problem and complicate control methods that can be made generally applicable to all cotton-growing areas. Under favorable circumstances, the wide range of naturally occurring enemies usually keep bollworms below economic damage levels. However, under unfavorable circumstances, due to factors not fully understood, bollworms may cause widespread damage to cotton. Also, the necessity of using insecticides to control the boll weevil and other cotton insects can so upset the natural balance that bollworms increase to levels that require costly control measures which at best are not highly effective. One of the greatest contributions to bollworm control will be realized if certain other important cotton insects can be eliminated or effectively controlled by other than insecticidal means or by the use of highly selective insecticides. In the meantime, it is urgent that major effort be devoted to research on ways to control bollworms when outbreaks occur and to develop supplemental control measures that will keep populations below economic damage levels. The research approaches and information needed are summarized in the items below.

2. Objective: Develop biological, chemical, and other methods that can be employed alone or properly integrated for controlling the two species of bollworm effectively and at low costs, thereby lowering the cost of cotton production; achieve effective and less costly methods of control without contributing to environmental pollution.

3. Research approaches:

- a. Investigate the seasonal development of bollworm species on various cultivated and wild host plants and appraise to what extent each major host plant contributes to bollworm populations in various cotton-growing areas; reappraise the damage potential of bollworm populations with a view to establishing reliable economic damage levels so that the need for insecticide or other treatments can be determined.
- b. Search for effective and selective chemicals and determine how their use can be properly integrated with biological and other control methods. Particular attention should be given to chemicals with possible new modes of action.

- c. Obtain information on the role of various natural parasites, predators, and diseases in controlling bollworms in various areas; determine how such natural agents can be augmented for more effective natural control; investigate the feasibility of mass production and employing parasites, predators, or diseases for the direct control of bollworms.
- d. Investigate the response of bollworms to physical and chemical stimuli, such as light and sex pheromones, and other physical factors and appraise their potential for practical control; or to employ them as tools for forecasting the need for bollworm control.
- e. Obtain necessary information on population fluctuations and population dynamics of bollworms as a basis for appraising the potentialities and feasibility of using the sterile male method for keeping bollworms below economic damage levels.
- f. Cooperate with plant scientists in the search for bollworm-resistant germ plasm in cotton and determine how useful bollworm-resistant varieties are for reducing losses caused by the two species of bollworms.
- g. Determine if and how cultural and crop management practices can contribute to bollworm control.
- h. Investigate the basic physiology and nutrition of the bollworms in search for new approaches to control and to develop information that will make mass rearing of bollworms feasible for use in the mass propagation of parasites, predators, or diseases, or for use as sterile males.
- i. Investigate the possibility of using radiation and chemo-sterilants to render the insects sexually sterile and the possibility of utilizing the sterility approach for control.

4. Character of potential benefits: Reduce costs of cotton production and lessen or avoid environmental pollution.

C. Pink bollworm control or eradication.

1. Situation: The pink bollworm is not now among the most costly of the cotton insect pests; however, it has the potential of being of major importance, especially in the arid, irrigated cotton-growing regions in the West. The recent spread of the insect into western cotton-growing areas could add another important factor to cotton production costs. The presence of the insect could not only reduce yields and necessitate additional costs for its control, but this in turn could complicate other insect control practices and create additional residue problems.

Thus, it is urgent to develop an expanded research program to adapt accepted control practices to the new areas and to explore the feasibility of developing possible new approaches to control and eradication, such as the use of sex pheromones or sterile male releases. In the event that eradication is not feasible or practical, it will be necessary to develop satisfactory methods for continuing control that involve minimum costs. The most important lines of work needing additional attention are itemized below under research approaches.

2. Objective: Avoid increases in cotton production costs by developing procedures for preventing further spread of the pink bollworm; reduce production costs by developing practical ways to eradicate populations; and provide for effective, economical, and safe methods of control where eradication is not feasible.

3. Research approaches:

- a. Investigate the biology, ecology, and seasonal population development and trends of the pink bollworm in various areas where it occurs so as to provide information necessary in formulating feasible and practical means of control or eradication.
- b. Develop safe, economical, and effective insecticides that can be used to supplement other control or eradication measures; fully investigate the role that the pink bollworm sex attractants can play directly in control and eradication programs, or indirectly by providing reliable means of forecasting when chemical treatments are necessary.
- c. Determine if and how natural or introduced exotic biological agents can be employed to help control the pink bollworm.
- d. Determine the role that sterile pink bollworms can play in preventing the spread of the insect to new areas and for the elimination of incipient or naturally low-level infestations; investigate the feasibility of employing sterile pink bollworm moths for eradication when integrated with cultural and/or chemical control procedures.
- e. Continue a search for pink bollworm-resistant germ plasm in plants and determine if resistant varieties will prove useful in pink bollworm control.
- f. Adapt known or develop additional cultural control practices for pink bollworm control in new areas of spread.
- g. Investigate the physiology of the pink bollworm and determine the nutritional and physical requirements necessary to achieve successful mass-rearing procedures.

4. Character of potential benefits: Prevent additional costs in cotton production by preventing the spread or by preventing the development of economic populations of the pink bollworm in the newly infested western areas; reduce losses in yield and quality of cotton by developing improved control or eradication procedures in areas where the pink bollworm is an established cotton pest.

D. Lygus bug control.

1. Situation: Lygus bugs are consistent pests of cotton in the irrigated Western States and cause occasional but a largely undetermined amount of damage in other cotton production areas. Damage due to the lygus bugs may result in yield losses of 3 to 4 percent per year on cotton. Lygus bug control is almost completely dependent upon insecticides. Although rather easily killed with chemicals, there are a number of problems resulting from their use, among which is an acquired resistance to many insecticides. The use of short-lived, broad-spectrum substitute chemicals, frequently on a repeated application basis, results in virtual elimination of most beneficial insects. Other pest species are then released from their normal biological regulatory agents and often build up rapidly to economic population levels. Some of these pests, such as the bollworms, spider mites, cabbage looper, and the like are difficult and costly to control on cotton with insecticides. In areas with persistent lygus bug problems, there is an urgent need for more sophisticated means of either controlling them on cotton or developing effective management on neighboring, more attractive alternate hosts, such as alfalfa.

2. Objective: Reduce losses in cotton yields caused by lygus bugs through host crop management practices and by developing selective chemical or biological means of control that do not adversely affect beneficial organisms in the environment.

3. Research approaches:

- a. Study the role that various cultivated and wild hosts play in the build-up of lygus populations and determine if appropriate management of cultivated host crops, such as alfalfa or certain wild hosts, will avoid or reduce lygus bug damage on cotton.
- b. Establish sound criteria for estimating the economic threshold density of lygus bugs on cotton and develop the most selective insecticides, including systemics and methods of use, that will achieve adequate control without upsetting the beneficial insect complexes. Particular attention should be given to chemicals with novel modes of action because of increasing resistance to available compounds.

- c. Investigate the various natural insect enemies of lygus bugs to determine practical ways of using them and/or augmenting their populations for practical control.
- d. Determine if lygus bug-resistant factors occur in cotton and through breeding incorporate such resistance into agronomically satisfactory varieties.
- e. Determine how cultivated host crops should be harvested or managed to reduce or avoid dispersal of lygus bugs into adjacent cotton-growing areas.
- f. Develop mass production methods for lygus bugs to make insects available for various studies, including the feasibility of mass producing specific parasites or predators for lygus bug control.

4. Character of potential benefits: Reduce losses in cotton yields; reduce costs of lygus bug control; avoid or minimize residue and other environmental hazards resulting from the use of persistent insecticides.

E. Spider mite, cotton fleahopper, cotton aphid, and other cotton pest controls.

1. Situation: There are dozens of insects and mites which attack cotton and which are not considered as key pests in efficient cotton production. Some are extremely and consistently important in limited areas and others are rarely important but may cause losses and require control measures occasionally. Damage and control costs cannot be categorized accurately but they are substantial. The losses in terms of reduced yields may approach 3 to 4 percent annually. Many species in this group would seldom reach serious population levels in the absence of upsetting factors such as chemical control of key pests which pauperize the ecosystem, releasing the other pests from effective biological regulations. Most of this group of pests are controlled successfully with chemicals although resistance is severe in some, like the spider mites. Until the problem of key pests is solved with more sophisticated techniques, it is anticipated that chemicals will remain the major means of applied control. Much important information is lacking about the biology, ecology, damage, etc., associated with this group. In the areas where there are recurring problems, research at an expanded level is considered necessary. For example, little is known about conditions which favor populations development. Importantly, information is lacking for most species on when populations reach levels requiring control measures. The relative importance of beneficial species is largely unknown, but this is essential information if integrated control programs are to be achieved. Some physiological research is underway, especially in the area of sex attractants, but such research in this large group of pests is fragmentary at best. Selective means of control, particularly selective insecticides, are vitally needed.

2. Objective: To develop information on the biology, ecology, and selective control of a complex of cotton insects and related pests to increase cotton production efficiency.

3. Research approaches:

- a. Investigate the biology, behavior, host plant relationships, and economic threshold density levels of insects and mites since such information is essential for the development of effective and sound control programs.
- b. Determine the most effective chemicals and the most practical way to employ such chemicals in an integrated program involving both the minor pests and the major pests.
- c. Determine the influence that different natural agents play in regulating the abundance of various species and to what extent parasites, predators, or diseases might be made more useful for controlling specific pests.
- d. Determine germ plasm in cotton that may impart resistance or tolerance to different insect species, particularly for the more important of the lesser cotton pests; any resistant germ plasm should be made available to cotton breeders for inclusion in their cotton breeding programs.
- e. Investigate and develop cultural measures for the control of specific pests.
- f. Develop means for rearing cotton insects of all kinds to facilitate research on various methods of control that may lead to practical and selective control measures.

4. Character of potential benefits: Reduce losses and increase cotton production efficiency by developing economical methods of control or by establishing when control measures are not needed.

F. Methods and equipment for insect control.

1. Situation: Cotton growers are now largely dependent upon chemicals for insect control. Special and costly equipment is needed for their application. Insects are developing resistance to insecticides and costs are increasing because of growing numbers of applications required. It is estimated that annual costs in materials, equipment, and labor required to control cotton insects exceed \$100 million annually. With present equipment and methods, not more than 20 percent of dusts applied adhere to the plant.

Sprays may be more efficient in adhering to the plants, but the efficient deposition of sprays to the parts of the plants where insects concentrate is far from satisfactory. Further knowledge of particle behavior during application should permit the use of less total pesticides and reduce the number of applications required. Special equipment is needed for applying systemic insecticides to soils or plants. The use of selective baits or selective attractants will also require the development of special equipment or devices. Ultra-low-volume applications and slow-release formulations offer much potential for increased effectiveness and reduced application costs. New and improved cultural practices requiring special equipment can be developed to assist in insect population suppression.

2. Objective: Develop new and improved equipment and techniques for chemical application and for cultural control to serve as part of a multi-disciplinary program to aid in suppression and control of cotton insects. All research will be cooperative.

3. Research approaches:

- a. Determine present efficiencies of available pesticide application equipment and develop new and more efficient principles and equipment for applying pesticides in lesser amounts, at more precise locations, in order to reduce the number of applications and the total amount of pesticide required; develop new equipment for the specialized use of new insect control chemicals.
- b. Evaluate present cultural practices for insect control and develop new equipment and techniques for substituting cultural for chemical control by suppressing insect populations rather than trying to control them after they have developed.

4. Character of potential benefits: Reduce production costs and lessen hazards due to chemical residues by decreasing the amounts of insecticides required for insect control.

Recommended Research Effort, RPA 207

TABLE 8.--Scientist man-year research requirements, RPA 207

Research Unit	Agency	Fiscal Year			
		1966 (SMY)	1969 (SMY)	1972 (SMY)	1977 (SMY)
A. Boll weevil control or eradication	USDA	28.0	35.0	40.0	40.0
	SAES	8.0	14.0	18.0	19.0
	Total	36.0	49.0	58.0	59.0
B. Bollworm control	USDA	13.0	21.0	29.0	35.0
	SAES	10.5	18.0	24.0	26.0
	Total	23.5	39.0	53.0	61.0
C. Pink bollworm control or eradication	USDA	8.0	13.0	18.0	18.0
	SAES	4.0	13.0	17.0	17.0
	Total	12.0	26.0	35.0	35.0
D. Lygus bug control	USDA	4.3	8.3	11.3	14.3
	SAES	2.1	11.0	14.0	14.0
	Total	6.4	19.3	25.3	28.3
E. Spider mite, cotton fleahopper, cotton aphid, and other cotton pest controls	USDA	4.3	7.3	12.3	17.3
	SAES	6.5	14.5	19.5	21.5
	Total	10.8	21.8	31.8	38.8
F. Methods and equipment for insect control	USDA	2.0	3.0	3.0	4.0
	SAES	1.0	3.0	3.0	4.0
	Total	3.0	6.0	6.0	8.0
RPA 207 Total	USDA	59.6	87.6	113.6	128.6
	SAES	32.1	73.5	95.5	101.5
	Total	91.7	161.1	209.1	230.1

Facility Needs to Support the Recommended Research Effort, RPA 207

Certain Federal facilities are now under construction that will meet some of the projected needs to support the USDA program. The Western Cotton Insects Research Laboratory at Phoenix, Arizona, which will be available in 1968, will provide facilities for 13 Federal scientists. The Federal Entomology Research Laboratory to be constructed at Stoneville, Mississippi, will provide facilities for 6 scientists working on cotton insect problems. However, the projection through 1977 calls for 69 additional Federal scientists above the FY 1967 level. Thus, no provisions have been made for 50 scientists. It requires about \$60,000 in facilities to adequately provide for each scientist. Therefore, additional facilities costing approximately \$3,000,000 will be needed by FY 1977. It is proposed that these needs be provided by expanding existing facilities at State College, Mississippi; Brownsville, Texas; Phoenix, Arizona; Florence, South Carolina; and College Station, Texas.

No facility requirements are projected to meet the needs for special research to be conducted concurrently to support any joint Federal-State-industry sponsored control or eradication programs that might materialize which would involve the use of sterile boll weevils or sterile pink bollworms. Neither do the projections provide for facilities and other needs for the mass production of boll weevils or pink bollworm moths needed in such programs. If major control or eradication programs are implemented which are based on the use of sterile insects as a major component in such eradication programs, special insect-rearing facilities of undetermined costs will be required but the costs, both Federal and State, would amount to several million dollars.

The facility requirements for the projected research programs by the State Agricultural Experiment Stations cannot be precisely determined. However, current facilities are already generally inadequate for current state scientists working on cotton insect problems. On the basis of projections for 70 additional scientists and a similar estimate of \$60,000 for facilities to support each scientist, the total SAES needs will aggregate about \$4,200,000 by FY 1977.

Research Problem Area 208 - Control of Diseases of Field Crops

Situation

Knowledge of the cost components encountered in the production and utilization of cotton is required for a comparative analysis of the elements of the proposed research system. The economic position of the cotton industry is markedly affected by this array of cost components, one of which is disease, and as such it has both direct and indirect functions. Indirect cost functions most clearly involve the overall inefficiency of the cotton plant. Although the specific elements of these functions are admittedly subtle, it is reasonable to note that the cotton plant made even its uneasy peace with the world of diseases at a significant cost when computed in terms of man's use of this plant today. Other indirect costs of disease, i.e., inefficiencies in cultural practices, limitations in land use, water loss, alterations of the environment through control efforts, etc., are not so subtle but are difficult to compute. Whatever the indirect costs, it is doubtful that the results of estimation procedures that might be used to detail such costs would contribute to the research system evaluation process. It is probably sufficient for this purpose to recognize that the goals of disease research are such as to be inherently inclusive of the need to reduce these indirect effects of disease on the production and utilization of cotton.

Direct costs of diseases of cotton are more readily estimated and include such functions as yield loss and reduction, growth impact, cost of control measures, reduction in quality of fiber and seed, etc. The estimates of these direct costs attributable to disease have been represented collectively as approximately 28 percent of costs incurred in the production of cotton. (No estimate of the cost of disease in the utilization of cotton and cottonseed is available.) The research system designed herein is proposed in part to reduce these losses to the cotton industry.

Inherent in designing a research system for control of plant diseases is recognition of the need to maintain controls now enjoyed and to anticipate emerging needs in light of an evolving level of scientific and technological knowledge. The former need can be estimated with a reasonable degree of sensitivity and is included in the research system presented herein. The anticipatory needs are more difficult to estimate with the degree of accuracy desired for a critical analysis. Guidelines for these estimations are to be found through interpretation of the implications of a vast array of currently emerging knowledge of a biological and biophysical nature. This knowledge is being generated not only on cotton but on plant and animal life in general. Additional guidelines are sought, in the historical sense, of the role of disease in plants, and especially the cotton plant. Thus, it is reasonable to anticipate shifts in the

biologics now involved, to recognize the gross impact of changes in cultural practices, to appreciate the implications of biochemical coding, and to calculate the effect of new stresses on the cotton plant as these relate to disease. All of these guidelines have been used and are reflected in the estimates presented in this system's approach to the solution of disease problems in cotton.

In preparing the estimates of research needs primary emphasis has been placed on determining the kinds of research that will provide the sophisticated level of knowledge required for the current and emerging problems. Recognizing that a high level of sensitivity in these estimates will contribute materially to the decision processes that will ultimately be used, aggregation of estimates were devised to most accurately identify the research activity needed. Thus, in consideration of the nature of this research, it is more significant to the decision process to have available aggregations of estimates of research needs, and the associated potentials, based on the activity involved, rather than having these predicated only on a given disease or causal agent and its importance. Using this rationale it has been possible to include estimates of the impact of such research as might be described as basic or fundamental, as well as more developmental or applied activities. Within reasonable limits the system can be claimed to be inclusive of the research effort and needs.

Specific Research Units, RPA 208

A. Diseases caused by pathogenic organisms (Etiology).

1. Situation: Organisms attack all parts of the cotton plant causing leaf spots, wilts, boll and root rots, and fiber and seed deterioration. Further studies are needed to determine the role of fungi, bacteria, and nematodes in the total disease syndrome.

2. Objective: To determine pathogens found infecting cotton plants, fiber, and seed, and to utilize information to ultimately attain greater production efficiency.

3. Research approaches:

- a. To determine new methods of isolation and identification of plant pathogens.
- b. To study the host response to these plant pathogens.
- c. To determine the role of microorganisms as secondary invaders.

- d. To determine the role of insects in transmitting disease organisms either directly or indirectly through feeding punctures.

4. Character of potential benefits: Reduce plant diseases and increase yield.

B. Diseases caused by pathogenic organisms (Epidemiology).

1. Situation: The epidemiology of pathogenic diseases, including host penetration, disease development, transmission, and physical characteristics, provides information that would lead to better methods of disease control.

2. Objective: To reduce losses.

3. Research approaches:

- a. To determine the means of invasion and colonization.
- b. What is the reaction of host in invasion of pathogens?
- c. What effects do pathogens have on host tissues in disease development?
- d. What stage of plant growth or boll development does infection occur?
- e. What plant morphological characteristics and physiological conditions stimulate or retard infection and disease development?
- f. How are pathogens carried over from season to season?
- g. What are the principal means of dissemination?
- h. What effect does seed storage conditions have on disease development?

4. Character of potential benefits: Improve seed and fiber quality and increase production.

C. Diseases caused by pathogenic organisms (Ecology).

1. Situation: Cotton grown in humid areas has a higher incidence of boll rot, fiber and seed deterioration, and foliar and root diseases. Control of diseases in the more humid parts of the Cotton Belt would lead to higher quality seed and lint, plus increased production.

2. Objective: To associate ecological factors with disease development, thus increasing quality of seed and fiber.

3. Research approaches:

- a. Determine the environmental conditions required for disease development.
- b. Improve seed storage conditions that will retard development.
- c. What are the effects of edaphic and ambient environment on the incidence and development of disease?
- d. Are conditions favorable for seed germination and seedling development also optimum for disease development?
- e. What effect does the environment (primarily temperature) have on seedling development that might vary its resistance to attack? This has been illustrated in relation to angular leaf spot.
- f. Selection of genetic material with lower optimum temperature for seedling growth.
- g. Cultural practices to eliminate the source of inoculum and decrease opportunity for disease development.

4. Character of potential benefits:

- a. Findings of this type information will aid in perfecting better storage methods for maintaining higher quality seed and stronger fiber.
- b. Better disease control methods for seedlings, plants and boll rot might be developed.

D. Response of the cotton plant to pathogenic organisms.

1. Situation: The cotton plant responds in a variety of ways to the presence of pathogens in or on the plant. The most obvious or apparent reaction is death of part or all of the plant, stunting, change in color of the foliage, and reduced or delayed fruiting. All of these symptoms represent a departure from normal behavior and indicate an upset in the physiological and biochemical make-up of the plant. Certain pathogens cause a change in the respiration rate, others impair translocation, and some reduce photosynthetic activity. In response to invasion the plant may produce new endogenous materials or increase the amounts of materials already present as a protective mechanism.

Such materials are referred to collectively as phytoalexins which are produced in response to irritation caused by the pathogen.

2. Objective: To determine the nature of the physiological and biochemical changes which occur in the plant as a result of pathogenic activity. Make critical comparison of physiological and biochemical activity in resistant and susceptible plants with a view to determining the nature of resistance and exploring the possibility of artificially inducing resistance. This latter possibility could be of great value since introduction of resistance factors, in many instances, has a deleterious effect on yield and lint quality.

3. Research approaches: Foliar or soil applications of micro-nutrients and other chemicals such as the substituted phenoxy compounds to induce changes in the endogenous materials, rendering the plant less susceptible or perhaps resistant to pathogens. By appropriate plant treatments, induce changes in the type and quantity of root exudates resulting in a changed microfloral population in the rhizosphere.

4. Character of potential benefits: Reduce plant diseases and increase yield.

E. Indirect methods of reducing disease losses.

1. Situation: For certain diseases of cotton, such as *Phymatotrichum* root-rot, no resistance has ever been found in any variety or species. The only control that is economically feasible is biological or cultural. Drastic changes in the quality and quantity of soil microorganisms result in an unfavorable environment for the pathogen while permitting normal development of the plants. Elucidation of the exact mode of action of the different segments of the associated soil microflora on soil-borne pathogens could greatly enhance control.

2. Objective: Determine the feasibility of controlling soil-borne cotton pathogens by manipulating the associated soil microflora.

3. Research approaches:

- a. Study the host-pathogen interaction as influenced by the number and kind of associated microorganisms.
- b. Develop reliable and repeatable bioassays for measuring the level of microbial activity necessary to obtain acceptable control.
- c. Change the vertical distribution of the pathogens, by appropriate cultural practices, to allow greater opportunity for the crop to escape infection.

4. Character of potential benefits: Reduce plant diseases and increase yield.

F. Disease control through resistant varieties.

1. Situation: Breeding for resistance is the cheapest and best method of disease control. In fact, with some diseases such as the wilts, the only economically practical control is resistance. When the mode of inheritance has been established and a source of resistant germ plasm is available, the development of resistant varieties is accomplished by cooperative effort between the pathologist and geneticist. Sources of resistance to several cotton pathogens are available but unfortunately resistance characters are often associated with agronomically undesirable characteristics. It is for the latter reason that efforts continue to be made to obtain higher levels of resistance while maintaining other desirable plant characters, yield, and fiber quality.

2. Objective: To increase production efficiency, yield, and quality through the transference of factors for resistance and search for additional sources of resistance germ plasm.

3. Research approaches:

- a. Determine the mode of inheritance of resistance in those diseases that are incompletely understood.
- b. Explore the possibility of breaking the apparent genetic association between resistance factors and undesirable agronomic characteristics.

4. Character of potential benefits: Reduce plant diseases and increase yield.

G. Control--biocides, fates.

1. Situation: Activity and mode of action of biocides in the soil, host, and pathogen are not known. Intensive use of chemicals and changing cultural practices in the growth of cotton have created new problems by altering the soil, physical and chemical, microorganisms and host physiology adversely affecting efficient crop production.

2. Objective: To more intelligently use agricultural chemicals, thus reducing residue and pollution problems.

3. Research approaches:

- a. Determine the fate of agricultural chemicals as affected by rate, mode, and time of application.

- b. Study the effect of agricultural chemicals on biotic populations and interactions with existing soil components.

4. Character of potential benefits: Reduce plant diseases and increase yield.

H. Microbial interactions.

1. Situation: Previous research has demonstrated that specific interactions among microorganisms in the soil frequently occur. In many instances, this may affect the microbial populations and have a vast effect on disease severity.

2. Objective: Results may lead to new methods of disease control.

3. Research approaches:

- a. Evaluate under controlled conditions the effects of various soil-borne parasites alone and in combination with other organisms.
- b. Beneficial associated soil microflora.
- c. What effects do various nutrients have on microbial populations where interactions exist?
- d. Are substances produced by roots of cotton or weeds that affect growth and development of nonparasitic organisms which enter into microbial interactions?
- e. Cultural practices.

4. Character of potential benefits: Reduce diseases.

I. Disease vectors.

1. Situation: The role of vectors of certain cotton disease organisms (Verticillium and Fusarium wilt) has not been fully developed. Evidence indicates that both parasitic and saprophytic nematodes play a major part in disseminating these two organisms. Other disease parasites may have vectors that are unknown and might have greater significance than has been realized.

2. Objective: To determine the role of vectors.

3. Research approaches:

- a. Relationship of nematodes and other soil fauna to dissemination of soil-borne fungi and bacteria.
- b. Effects of irrigation water on dispersal of nematode and other vectors.
- c. Vectors of viruses.
- d. Relationship of insect-transmitted fungi and bacteria to boll rot.

4. Character of potential benefits: Reduce losses.

J. Toxins--bacterial, fungal, nemal.

1. Situation: The effects of toxins produced by microorganisms are incompletely known and additional study is needed.

2. Objective: Determine the effect of toxins produced by microorganisms to the cotton plant and explore the feasibility of eliminating their effect.

3. Research approaches:

- a. Identify the role of various microorganisms in toxin production.
- b. Determine the host-toxin reaction and methods essential to nullify their effect.

4. Character of potential benefits: To reduce or remove the losses resulting from this cause.

K. Disease interactions--growth regulators and biocides.

1. Situation: Added chemicals and biocides have been shown to alter the endogenous and edaphic conditions of cotton plants affecting disease development. This is a relatively new area in plant pathological research which should be investigated.

2. Objective: To study the level of biocides and growth regulators in the plant to produce the necessary results.

3. Research approaches: Determine the types of chemicals and biocides inducing an effective host response.

4. Character of potential benefits: Reduce diseases.

L. Diseases of weeds.

1. Situation: Weeds may serve as a source of inoculum for cotton plant infection and as reservoir for future inoculum.

2. Objective: To determine the susceptibility of various weed hosts to microorganisms attacking cotton.

3. Research approaches: In controlled experiments various weed hosts will be inoculated and the plant responses studied. This will provide valuable information for reducing this production hazard in cotton.

4. Character of potential benefits: Reduction of plant diseases.

Recommended Research Effort, RPA 208

TABLE 9.--Scientist man-year research requirements, RPA 208

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Diseases caused by pathogenic organisms (Etiology)	USDA	2.3	2.2	2.1	2.0
	SAES	1.0	1.9	2.0	2.7
	Total	3.3	4.1	4.1	4.7
B. Diseases caused by pathogenic organisms (Epidemiology)	USDA	0.9	1.2	1.4	1.8
	SAES	0.8	1.5	1.6	1.9
	Total	1.7	2.7	3.0	3.7
C. Diseases caused by pathogenic organisms (Ecology)	USDA	0.6	0.9	1.2	1.4
	SAES	1.4	2.5	2.9	3.2
	Total	2.0	3.4	4.1	4.6
D. Response of the cotton plant to pathogenic organisms	USDA	2.0	3.5	4.8	6.6
	SAES	2.5	6.2	9.0	12.6
	Total	4.5	9.7	13.8	19.2
E. Indirect methods of reducing disease losses	USDA	4.4	3.0	2.9	2.4
	SAES	5.6	8.1	10.5	13.0
	Total	10.0	11.1	13.4	15.4
F. Disease control through resistant varieties	USDA	2.7	2.8	2.8	2.9
	SAES	1.3	2.1	3.3	3.8
	Total	4.0	4.9	6.1	6.7

(continued)

TABLE 9.--Scientist man-year research requirements, RPA 208 (continued)

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
G. Control--biocides, fates	USDA	3.8	5.1	6.3	8.0
	SAES	3.8	7.5	9.4	11.0
	Total	7.6	12.6	15.7	19.0
H. Microbial interactions	USDA	1.2	2.3	3.5	4.6
	SAES	7.2	8.5	11.0	13.0
	Total	8.4	10.8	14.5	17.6
I. Disease vectors	USDA	0.0	0.1	0.3	0.5
	SAES	0.3	1.2	2.2	3.0
	Total	0.3	1.3	2.5	3.5
J. Toxins--bacterial, fungal, nemal	USDA	3.0	3.8	4.2	5.0
	SAES	0.1	1.2	2.2	2.8
	Total	3.1	5.0	6.4	7.8
K. Disease interactions--growth regulators and biocides	USDA	1.5	1.8	2.3	3.0
	SAES	0.5	1.5	3.0	4.3
	Total	2.0	3.3	5.3	7.3
L. Diseases of weeds	USDA	0.5	1.0	1.6	2.0
	SAES	0.2	0.4	0.7	0.9
	Total	0.7	1.4	2.3	2.9
RPA 208 Total	USDA	22.9	27.7	33.4	40.2
	SAES	24.7	42.6	57.8	72.2
	Total	47.6	70.3	91.2	112.4

Notes

(1) All estimates are inclusive of research on disease and abnormal physiology of cotton production - utilization.

(2) Nematological research pertinent to cotton is included herein.

Facility Needs to Support the Recommended Research Effort, RPA 208

The research outlined in RPA 208 can be solved more rapidly and accurately in facilities where environmentally controlled experiments might be conducted. It is recommended that three facilities be erected for State use at three University Experiment Stations--one in the Piedmont, a second in the Delta, and a third in the High Plains.

Each facility would consist of greenhouses and an adjoining laboratory building designed for controlled studies. Such facilities might be more expensive; however, there is an urgent need for facilities of this type.

1. Piedmont Area	1969	\$1,000,000
2. Delta Area	1971	\$1,000,000
3. High Plains Area	1973	<u>\$1,000,000</u>
Total		\$3,000,000

Research Problem Area 209 - Control of Weeds and Other Hazards of Field Crops

Situation

Man has contended with weeds in cotton since introduction of this crop into the United States. Weeds reduce yields, increase cost and labor requirements, and generally interfere with all phases of cotton culture. They are one of the most serious problems in cotton production.

Difficulties are encountered in defining weeds since plants that are important crops in one situation can easily become weeds in other situations. As a result, most of the old definitions, such as that of Emerson, "A plant, the virtues of which have not been discovered," fall short of being acceptable, leading to perhaps the best definition, "A plant growing where it is not wanted." Thus, in cotton production all plants except the cotton plant itself became weeds.

In the United States more than \$2.5 billion is spent annually to control weeds. Average annual losses in cotton have for several years approximated 8 percent of the total crop.

A wide variety of annual and perennial grasses, sedges, and broadleaf weeds constitute major production problems in cotton. Herbicides have been used extensively in recent years to control weeds but a lack of adequate ones specific for the control of major problem weeds has resulted in invasion of thousands of acres of the more productive cotton land by johnsongrass, nut-sedge, and annual and perennial broadleaf weeds. Losses result from (a) direct losses due to weeds, (b) reductions in fiber quality and mechanical harvesting and ginning efficiency, and (c) increased labor requirements in all phases of cotton production because of the presence of weeds.

A. Direct losses attributable to weeds.

1. Yield reductions: Heavy weed growth may reduce cotton yields more than 50 percent.
2. Growth reduction of cotton plants: Presence of early season weed growth sharply reduces growth and vigor of cotton plants, greatly reducing the competitive ability of cotton to subsequent weed problems even if the original weed problem is eliminated.
3. Insect control problem: Weeds harbor insects making them more difficult to control and increasing the number of required insecticide applications. An example is the heavy infestation of cutworms that often migrate into cotton from adjacent "skip" areas that are overgrown with winter weeds.

B. Losses due to reductions in cotton fiber quality and mechanical harvesting and ginning efficiency.

1. Delayed cotton maturity: Heavy weed growth may directly delay cotton boll maturity but even relative light infestations of vines such as morning-glory may delay optimum harvest dates. Timely harvesting is often essential to highest grades of lint cotton.
2. Ginning efficiency: Presence of weeds at harvest increases trash and debris in harvested seed cotton. Trash is often difficult to remove in ginning and "overginning" may mechanically weaken cotton fibers, making cotton extremely difficult to spin. Late-season grass weeds in the irrigated region of the Southwest may reduce cotton quality one or two grades.
3. Increased moisture in seed cotton: Weeds harbor moisture following humid nights and often delay mechanical harvesting on a daily basis. Harvesting of seed cotton with excessive moisture leads to "over-drying" which can seriously reduce quality of cotton lint.
4. Reduction of fiber quality due to trash: Leaves of grass weeds often have high SiO_2 content. Leaf fragments from these weeds become strongly imbedded in cotton fibers during mechanical harvesting and ginning and may seriously reduce fiber strength. Damaged cotton lint is more difficult and more expensive to spin.

C. Effects of weeds on pre- and postplanting cultural practices.

1. Preplanting operations: Preplanting cultural practices such as disking, harrowing, and related practices are frequently applied primarily or entirely to remove weed growth.
2. Planting: For decades the conventional initial step in cotton production has been planting on a previously formed seedbed. The primary intent of this bed is threefold--surface drainage, weed control, and moisture conservation. In many situations, drainage is no longer the primary consideration since "shaped" fields provide adequate surface drainage. Similarly, moisture conservation would not be a determining influence on the use of prior formed beds if herbicides were available to control weed growth preplanting. In many situations the expensive labor and equipment consuming practice of bedding can be directly attributed to the control of weeds.
3. Postemergency cultivation practices: Producers conventionally cultivate row middles 3 to 5 times annually to control weeds. Availability of adequate herbicides would eliminate this need and result in marked savings through reductions in manpower and equipment needs.

The above outline summarizes only the major influences of weeds in cotton production. Many of these problems are interrelated so that specific problems caused by weeds are difficult to define. For this reason weed control in cotton must be considered as a portion of an integrated production program rather than as a separate science.

In many areas, such as the Mississippi River Delta, intensive use of pre- and postemergence herbicides has provided excellent control of annual broadleaf and grass weeds. Farmers in the Mississippi River Delta use pre- and postemergence herbicides on approximately 500 percent of the total cotton acreage. This demonstrates that essentially all acreage receives preemergence treatment and that each acre of cotton receives four postemergence herbicide treatments. These practices are supplemented by spot applications of herbicides and hand hoeing. The available source of hoe labor has decreased quantitatively and qualitatively making herbicides in cotton production essential. The advents of high speed cultivation, flame, and herbicides enabled cotton producers to reduce costs and losses because of weeds, but mainly the effect of these advances was to permit continued production in spite of dwindling labor supplies, rising costs of machinery, and decline in price of cotton. The newer herbicides are highly specific, and we have an increasing need for safer herbicides, or mixtures, that control a wider spectrum of weeds.

The need for additional research in Weed Science will undoubtedly increase through at least the next 10 years. This is because the remaining problems become more difficult as the easy ones are solved, and because trained research personnel to provide adequate staffing is not available currently. The large number of weed species affecting cotton, coupled with the small number of scientists working on the problems, has not permitted the intensive effort against individual species that has been so effective against insect and disease pests.

Specific Research Units, RPA 209

A. Johnsongrass control or eradication.

1. Situation: Sorghum halepense L. Pers. (Johnsongrass) is a stiff, erect perennial that often grows to a height of 6 to 8 feet. Growing conditions most optimum for cotton production also favor rapid growth of johnsongrass. This weed is troublesome in all cotton producing states.

Johnsongrass is more difficult to control than most weeds because it reproduces vegetatively (through underground stems called rhizomes) and by seed. Johnsongrass produces rhizomes and seed vigorously and a large proportion of its seed is hard seed. These hard seed may lay in the soil under ideal germinating conditions for years before germinating. Thus, even though an intensive effort is made to eradicate rhizome and seedling johnsongrass, continued vigilance is necessary to prevent reinfestation from seed. Plants from seeds remain "seedlings" only for 3 to 4 weeks before producing rhizomes and becoming perennial plants.

Available programs that will consistently provide 85 to 95 percent control cost \$15 to \$20 per acre and require hand labor. In most situations, it is difficult to obtain more than 95 percent control without excessive increases in both cost and labor. The type labor used in previous years for mid- to late-season spot control of johnsongrass does not exist at present.

2. Objective: To control and eventually eradicate johnsongrass.

3. Research approaches:

a. Chemical control.

1. More effective foliar-applied herbicides that will translocate to and control rhizome growth.
2. Germination inhibitors and stimulators on both rhizome buds and seeds.
3. Selective herbicides with long soil residual for preemergency control of seedlings.
4. Alternate herbicide usage--evaluation to find herbicides which increase susceptibility of johnsongrass to subsequent herbicide treatments.
5. Use of various additives to increase penetration and translocation of herbicides.

b. Cultural or mechanical.

1. More effective practices for cultural control with emphasis toward fallowed fields.
2. New and improved methods of applying herbicides to johnsongrass to increase efficiency of control.
3. Cropping and rotation studies to develop more competitive cropping situations toward johnsongrass.

4. Crop-competition studies to more accurately analyze effects of johnsongrass.

c. Biological.

1. Insects.
2. Diseases.

d. Other.

1. Ecotypes or strains of johnsongrass exist which vary markedly in their response to more effective johnsongrass herbicides. Additional research is needed to permit an accurate estimation of potential problems that could be caused by specific hard-to-control ecotypes.

4. Character of potential benefits: Increased efficiency of cotton production through reduced crop losses and increased quality of cotton fiber.

B. Nutsedge control or eradication.

1. Situation: Nutsedge /Cyperus rotundus (L.) and Cyperus esculentus (L.) is recognized throughout the cotton growing areas of the United States as one of the most troublesome weeds during the early stages of establishment and growth of the cotton plant. It competes vigorously with cotton for water, nutrients, and light.

Severe nutsedge infestation often causes both mechanical difficulties in cotton planting and a subsequent reduction in the cotton stand. Areas where nutsedge reduces crop stands later become more highly infested with nutsedge and other weeds due to the lack of competition by the cotton plant.

Reproduction of nutsedge by seed is insignificant, but single tubers can produce as many as 1900 new shoots and 6000 new bulbs and tubers within one growing season. The complex shoot, rhizome, tuber, and basal bulb system makes vegetative propagation rapid and vigorous, and control very difficult.

2. Objective: Eradication or control of nutsedge.

3. Research approaches:

a. Chemical.

1. Conduct extensive evaluation program to find more effective herbicides for nutsedge control.
2. Develop more efficient methods for herbicidal applications.

b. Physiological.

1. Determine mode of action of effective herbicides to aid in more effective designs for future research procedures.
2. Determine the pattern and the mechanism of absorption and translocation of herbicides into and within the nutsedge plant in an effort to obtain more effective kill of all the vegetative portions of the weed.
3. Determine the most susceptible stage in the life cycle of nutsedge plant to herbicidal control, and determine methods for obtaining uniform growth patterns of nutsedge in an effort to induce a susceptible growth stage within the largest possible number of plants at one time.

c. Biological.

1. Insects.
2. Diseases.

d. Mechanical.

1. Develop more efficient machinery for preparation of suitable seedbeds within nutsedge infested areas.

4. Character of potential benefits: Reduce cost in seedbed preparation, improve cotton stands, and promote more efficient utilization of soil moisture and nutrients by the cotton plant.

C. Sida control.

1. Situation: Sida spinosa (L.) (sida), a weed in the same family as cotton, has very recently become a serious problem in the production of cotton. The rapidity with which sida became a serious weed in cotton vividly illustrates a dynamic change in ecology by man's production practices.

Sida has developed into a serious threat to cotton production during the past three years. Previously, cotton was treated with a preemergence herbicide on a narrow band, and cultivation was used to control weeds between the rows. Recently, a new herbicide was introduced for preplanting incorporated broadcast application which was not as effective on sida as the former herbicide, but which gave excellent control of annual grasses for relatively long periods. As large acreages were treated with the new herbicide and cultivation was used less, sida became more of a problem.

Sida in cotton producing areas is not of recent origin, but concern over its increasing presence is recent. Sida was cited six times in the 1967 Research Report of the Southern Weed Conference, but only once in reports of the previous three years. A survey conducted through farmers and county agents of the Mississippi River Delta in 1965 did not show sida among the eight weeds occurring most frequently in cotton. However, in 1967, one of the questions most frequently asked by cotton producers is "What will control sida?"

2. Objective: To develop practices for economical control of sida in cotton.

3. Research approaches:

a. Chemical control.

1. Evaluation of new pre- and postemergence herbicides for activity on sida.
2. Evaluation of new methods of applying present herbicides for sida control.
3. Evaluation of additives with present herbicides for sida control.
4. Evaluation of highly toxic but nonselective herbicides to selectively kill sida in cotton by the use of thickening agents in the spray and specialized applications.

b. Cultural control.

1. Development of cultural practices to complement herbicides for controlling sida during the crop season.
2. Development of practices with a high degree of effectiveness for sida control which can be used when cotton is not on the land.

4. Character of potential benefits:

- a. Reduce crop losses.
- b. Increase lint quality
- c. Reduce cotton production costs.

D. Cocklebur control or eradication.

1. Situation: Xanthium spp. (cocklebur) plants 6 to 8 feet tall with upwards to 2,000 fruits (burs) are common in many cotton fields. Plants may emerge as late as August, grow only 5 inches tall, and set only 2 to 6 burs in fields where concerted efforts were made to control this pernicious weed.

Six species of cocklebur are listed in the 1966 WSA Terminology Committee Report: Xanthium echinatum Murr., beach; pensylvanicum Wallr., common; italicum Moretti, Italian; chinense Mill., oriental; speciosum Kearney, showy; and spinosum L., spiny. Xanthium pensylvanicum Wallr. (common cocklebur) reportedly occurs most frequently in Midsouth cotton fields. It is distributed from Florida to Texas and southern California, north to Quebec.

Current control methods include combinations of preemergence treatments of substituted ureas; postemergence treatments of arsenicals, ureas, flame, herbicidal naphtha; cultivation; and layby applications of ureas. The best of our combinations control less than 80 percent of the cockleburs, and control of the remaining 20 percent is needed for a complete program. Available methods do not meet this need.

Cocklebur has several characteristics which limit control with current methods:

- a. Flowering is photoperiodic which enables even the smallest plants to produce viable seed.
- b. Because of the large seed size, germination occurs from deep depths over long periods of time. If the seed coat is punctured, germination is increased.
- c. Assuming perfect control of all plants up to "layby" application, reinfestation will occur from seedlings emerging after layby from those seed which did not germinate earlier because of oxygen deficiency.
- d. The fruit (bur) contains two seeds which have different germination requirements. Both seeds are suspected of containing a germination inhibitor which requires oxidation to allow germination. The upper seed in the bur is thought to contain a higher quality of inhibitor; hence, longer oxidation periods. Further, the upper seed is less permeable to oxygen.

Burs of cocklebur are almost impossible to remove from cottonseed. Hand removal is impractical. After delinting, cocklebur and cottonseed are practically the same size and density.

2. Objective: To reduce cocklebur to infestation levels which do not affect cotton production or which can result in eradication.

3. Research approaches:

a. Chemical control.

1. More selective herbicides.
2. Practices which will control cocklebur after layby to supplement present methods.
3. Compounds to disrupt the oxygen-inhibitor relationship.
4. Compounds to prevent flowering, fruit set, or embryo development.
5. Germination inhibitors and stimulators.

b. Cultural or mechanical.

1. Practices to damage seed to allow oxygen uptake.
2. Techniques to permit disruption of the photoperiod to prevent flowering.
3. Alteration of soil conditions to increase oxygen content, either chemically, biologically, or mechanically.
4. Crop rotation, competition studies.
5. Ecological shifts induced by alteration of environment, specifically the microclimate.

c. Biological.

1. Insects.
2. Diseases.

d. Other.

1. Better methods of removing cocklebur from cottonseed.
2. Breeding for male sterility.

4. Character of potential benefits: Increased harvest efficiency, reduced crop losses, higher quality planting seed, and reduction in production costs.

E. Annual grasses and sedges control.

1. Situation: The annual grasses, Brachiaria spp. Ledeb., Digitaria spp. Heist. (crabgrass), Panicum capillare L. (witchgrass), Echinochloa crusgalli (L.) Beauv. (barnyardgrass), Eleusine indica (L.) Gaertn. (goosegrass), Leptochloa filiformis (Lam.) Beauv. (red sprangletop), and annual sedges cause serious damage to cotton under many conditions. Almost all cotton acreage contains potential populations for severe damage by these weeds. Prolonged wet weather immediately before planting hinders the effectiveness of preplanting and preemergence herbicides or prevents the use of cultural pre- and postemergence practices. Current herbicides control most of these grassy weeds effectively, but the minimum cost for dependable control exceeds \$7 per acre. Lack of more effective and economical weed control practices increases cost and lowers efficiency and returns.

2. Objective: Control and eradication of annual grasses and annual sedges.

3. Research approaches:

a. Cultural control.

1. Modification of land management to allow more timely cultivation than that usually possible following wet conditions.
2. Modification of equipment to work more effectively under wet conditions.

b. Herbicidal control.

1. Preplanting herbicides.
2. Preemergence herbicides.
3. Postemergence herbicides.
4. Intensive evaluation or preplanting, pre- and postemergence herbicides in all combinations to provide absolute weed control.

c. Character of potential benefits: Reduce crop losses through eventual eradication of annual grasses and sedges.

F. Annual broadleaf weeds control.

1. Situation: Despite rapid advances in the chemical control of annual weeds in cotton, there are several species of broadleaf weeds that continue to be troublesome. A list of the more troublesome broadleaf species follows:

<u>Common Name</u>	<u>Scientific Name</u>
morning-glory	<u>Ipomoea</u> spp.
pigweed	<u>Amaranthus</u> spp.
common purslane	<u>Portulaca oleracea</u> L.
Florida purslane	<u>Richardia scabra</u> L.
lamsquarters	<u>Chenopodium album</u>
ragweed	<u>Ambrosia</u> spp.
ground cherry	<u>Physalis</u> spp.
puncture vine	<u>Tribulus terrestris</u> L.
poor joe	<u>Diodia teres</u> Walt.

Most of these weeds occur throughout the entire cotton producing area. The degree of infestation and problem of control vary, however, with the area or within specific fields. Practices are generally available which will provide an acceptable level of control if applied correctly, but often several herbicides are required if all species are to be controlled. With low levels of weed control, the entire crop may be lost or returns drastically reduced. Weed infestations tend to increase the incidence of insect and disease damage to crop. Cotton boll rot is greatly aggravated where a canopy of weeds reduce air circulation around the lower bolls.

2. Objective: To develop practices for more economical control of annual broadleaf weeds in cotton.

3. Research approaches:

- a. Evaluation of present and new herbicides applied pre- and post-emergence for selective control in cotton.
- b. Evaluation of additives and specialized methods of application to achieve better control.

- c. Investigation of preconditioning a given species by the application of one herbicide so that application of a second or third herbicide will greatly increase control.
- d. Investigation or mechanism of germination so seeds can be either stimulated to sprout and the seedling subsequently killed, or else the seed germination can be inhibited.
- e. Investigation of biological control by use of insects with specific feeding habits.
- f. Evaluation of the use of cultural practices such as tillage and flame alone and in conjunction with herbicides for maximum control.

4. Character of potential benefits:

- a. Reduce crop losses.
- b. Increase lint quality.
- c. Reduce cotton production costs.

G. Bermudagrass control.

1. Situation: Cynodon dactylon (L.) Pers. (bermudagrass) is a perennial propagated by seed and stolons. Intensive cultivation as now practiced in cotton production tends to control bermudagrass, but control might become a problem when the soil surface is not disturbed during the growing season. Continued reduction in available labor for hand hoeing could also intensify this weed problem.

2. Objective: Control or eradicate bermudagrass.

3. Research approaches:

- a. Cultivation plus herbicides prior to planting.
- b. More selective herbicides.
 - 1. Evaluation program.
 - 2. Methods of application.

4. Character of potential benefits: Reduce cost of cotton production.

H. Perennial broadleaf weeds control or eradication.

1. Situation: Ampelamus albidus (Nutt.) Britt. (honeyvine milkweed) reproduces by seeds and by long spreading roots. It is troublesome in fertile, moist soil. It climbs cotton stalks, causing a reduction in cotton yield and quality. Milkweed reduces the picking efficiency of mechanical pickers.

Brunnichia cirrhosa Gaertn. (redvine) is a woody vine with extensive root systems which spread over wide areas to considerable depths, particularly in heavy soil. It seldom produces seed in cultivated fields. Where redvine grows undisturbed, it climbs any available support and produces seed, but in cultivated fields, it reproduces primarily from extensive root systems.

Tillage has been used alone and in combination with herbicides to control redvine. Tillage to a depth of 30 inches at various distances in combination with postemergence application of the triethanolamine salt of 2,4-dichlorophenoxyacetic acid (2,4-D) did not give any control the following year. Deep tillage did not influence the effectiveness of 2,4-D, but split applications of 2,4-D were more effective than a single application at an equal rate. Tillage frequency was studied by regular disking at various intervals from 14 to 42 days. The following season showed little control from 2 to 8 diskings.

Solanum carolinense L. (horsenettle), Convolvulus arvensis L. (field bindweed), Campsis radicans (L.) Seem. (trumpet creeper), Ipomoea pandurata (L.) G.F.W. Mey (bigroot morning-glory) have also caused severe localized weed control problems in cotton. All of the above mentioned weeds could produce national problems as labor for hand hoeing diminishes. Selective herbicides are not available for the control of these in cotton.

2. Objective: To develop methods to control and eradicate perennial broadleaf weeds in cotton.

3. Research approaches:

a. Cultural.

1. Fallow cultivation plus herbicide.
2. More effective cultivation in cotton.

b. Herbicides.

1. Evaluation for more selective herbicides.
2. Evaluation for more effective applications.
3. Evaluation of additives to increase herbicide toxicity.
4. Evaluation of alternate herbicide usage.
5. Evaluation of penetration, translocation, and absorption of herbicides to increase effectiveness.

c. Biological.

1. Insects.
2. Diseases.

4. Character of potential benefits: Control of perennial broadleaves would increase yields, harvest efficiency, and quality--reducing cost of production.

I. Winter weeds control or eradication.

1. Situation: Winter weeds such as Stellaria media (L.) Cyrillo (chickweed), Lamium amplexicaule L. (Virginia pepperweed), Poa annua L. (annual bluegrass), and several wild mustards infest most cotton acreage during the winter season. This vegetation has to be eliminated prior to planting cotton and usually at least two cultivations or diskings are needed. Elimination of one cultivation would result in savings of more than \$9 million annually. Winter weeds also harbor cotton insects in early growing season.

2. Objective: Control and eradicate winter weeds.

3. Research approaches:

a. Cultural methods.

1. Cultivation-herbicide-interaction studies to control winter weeds and eliminate current repeated cultural practices.

b. Herbicidal methods.

1. Intensive evaluation of herbicides to destroy all winter vegetation at reduced costs.
2. More effective utilization of herbicides to control winter weeds, time of application, rate studies, etc.

4. Character of potential benefits: Reduce costs of cotton production by eliminating preplanting cultivations and insecticide applications.

J. Biological control of individual weed species.

1. Situation: Frequently, the use of insects as biological control agents is stressed but higher plants, microorganisms, and animals are biological agents of possible value for the control of weeds. Relatively few attempts have been made to use biological methods of weed control that would have direct bearing on protecting cotton.

The use of geese to control grasses and nutsedge represents the most successful attempt to use biological agents for control of weeds in cotton. From the reports published thus far, it appears that profitable use of geese is likely only on smaller farms where extensive management and supervision could be provided. Complications involving insecticides, supplemental feeding, watering, and protection from predators may render their use on large acreages impractical.

The research area offering the most potential for significant advances in the biological control of weeds is undoubtedly a concerted multidiscipline attack against selected individual species of weeds. The chances for finding biological agents that attack a limited number of plant species, perhaps only one, are better than for finding an agent which attacks many species of weeds without posing a threat to cotton or rotational crops.

The use of Fasarium oxisporum Schlect. to control cactus in the Hawaiian Islands, the effective control of pricklypear in Australia with the moth Cactoblastus cactorum Berg., the joint infestation of grain sorghum and cotton by nematodes in Texas, the elimination of chestnut by blight in the United States, the extreme variability in ecotypes of johnsongrass in research plots in Mississippi, and numerous other investigations demonstrate clearly the feasibility of obtaining success in controlling specific weeds with biological agents. Our chances of success would be greatly increased if a joint attack by several disciplines were directed against specific weeds such as johnsongrass, nutsedge, perennial morning-glory, or other weeds difficult to control through use of current herbicides and cultural control practices. Valuable disciplines in such a multidiscipline approach would include biologists familiar with both the target plants and with the biological agents that attack them; geneticists who could alter resistance and susceptibility in the target species of weeds and in cotton; physiologists who could assist in the elucidation of effects produced by the biological agents on the target species and on cotton; and engineers and agronomists who could assist in the development of practical means of implementing the findings uncovered by the other researchers.

Natural processes of selection tend to build resistance in weeds and crops to biological enemies within the same geographical region. Because of this, surveys and research to find natural enemies of our weeds in foreign lands is a logical approach to finding effective agents. Once effective agents are discovered, means of developing satisfactory methods of introduction into the problem area and research to insure protection against adverse side effects are essential. Because of the complexity of the problem, individual efforts are unlikely to lead to significant advances, and particularly if such individual efforts are broadly directed against weeds in general. On the other hand, we believe that concerted efforts against single species of weeds have a high probability of succeeding.

Currently, one Research and Marketing contract totaling \$118,000 is being conducted within the Crops Research Division to explore the potential of controlling weeds biologically with plant disease organisms. Also, the Entomology and Crops Research Divisions are cooperating in supervision of PL 480 projects totaling \$109,000 to find insect enemies of weeds in foreign countries. Much of this search is devoted to finding biological agents for control of aquatic weeds, but an effort is being made with some success to find insects which will attack nutsedge and other terrestrial weeds. Both the Research and Marketing contract research and the PL 480 projects are general in nature, and are not directed specifically at the control of weeds in cotton. Cotton, however, potentially could benefit from any of these investigations. There is no Federal nor State research now being devoted to developing methods for controlling weeds in cotton through use of biological agents, except for a small effort on the use of geese and farm animals to selectively graze some weeds. The discovery of effective biological agents will be of little value unless immediate efforts can be made to develop practical ways of using the findings against the target weeds.

2. Objective: To discover and develop practical biological controls for specific weeds (such as johnsongrass, nutsedge, and perennial morning-glory) that are serious pests in cotton, and which are difficult to control by present chemical and cultural methods.

3. Research approaches:

- a. Conduct domestic and foreign surveys to discover biological agents to which the target weeds are susceptible and to which cotton shows some degree of tolerance. Both domestic and foreign surveys are needed because weeds tend to develop resistance to natural enemies in the region where both exist. By extending the surveys to foreign countries, we hope that species and strains of organisms can be found to which domestic weeds are highly susceptible.

- b. Once effective biological agents are discovered, develop practical methods of propagation and introduction in practical quantities into the problem areas, and simultaneously evaluate and develop methods of preventing adverse side effects from attacks against plants other than the target weeds. Massive inoculation of large areas with the biological agents is unlikely to prove practical. Therefore, seeding and rapid proliferation after seeding, with the biological agents, appears to be a logical approach to the problem in bringing high populations of the biological agents to bear against the target species of weeds. Concurrently, with such efforts, we must evaluate the possibility that the agent will attack not only the target species but move on to desirable plants or possibly other organisms in our environment. Starvation of the biological agent in the event of target eradication is one possibility, but more direct methods of eradicating the biological agent once the job was done should be considered part of the overall development. Machinery and methods for introducing the agent will be an essential part of this facet of this research approach.
- c. Conduct genetical studies designed to increase the virulence of the agents on weeds and the resistance of cotton to effective biological control agents. Breeding crops for resistance to disease and insects has been highly successful. We believe that such principles could be extended to breeding for increased resistance of cotton to imported biological agents, and to increasing the virulence of the agent on the weeds.

4. Character of potential benefits: Several weeds such as johnsongrass, nutsedge, and perennial morning-glory are difficult to control with current chemical and cultural practices. Often these weeds cause failures in control programs which would have been adequate for the control of other major weed species. Biological control offers a logical possibility for eradicating specific species of weeds from a particular geographical area of crop production. Such control could possibly be achieved through inexpensive introduction of the biological agent into the area, followed by spontaneous proliferation until near eradication of the target species had been achieved.

K. Problems created by weed control measures.

1. Situation: The control of weeds in cotton obviously alleviates problems, but almost all the methods now used tend to create new problems. Naturally, it is essential that the new problem be less serious than the original, and steps must be taken to avoid or minimize the adverse side effects.

Fumes from the internal combustion engines of tractors and aircraft, creation of dust, and volatilization of herbicides contribute to the pollution of the atmosphere to some degree. The burning of weed growth before planting certain crops other than cotton is a serious problem in localized areas. Thus far, it has not appeared to be a major problem in cotton production, but could be under special circumstances in localized areas.

Traffic of tractors and other application machinery contributes to problems of soil compaction, particularly when done under conditions where the soil is wet.

Perhaps the most extensive and potentially hazardous problems created by the use of weed control methods in cotton involve residues of herbicides in soils, plants, and water. Herbicides that are too persistent may injure cotton and rotational crops planted in succeeding years. Currently, serious aftereffects are being avoided through restrictions in the species of crops to be planted following application of most of our herbicides. To date, we have had little injury to cotton from herbicides applied the previous year for control of weeds in cotton, but there have been some exceptions. Somewhat more frequently, there have been cases of injury to crops following cotton such as soybeans and vegetable crops.

Only very low residues of herbicides in crop products used for food or feed are permissible under existing laws, rules, and regulations. Although we have little or no evidence that herbicides now used for controlling weeds in cotton present hazards to men or animals through residues in the seed of the crop, we are able to detect low levels of many of the herbicides in the seed. The maximum safe level of these residues must be established for each herbicide, and research to keep residues well below the safe level is essential.

When herbicides are applied in fields for controlling weeds, some of the material may contact various parts of our water resources. Direct drift to nearby streams is one means of such contamination. Perhaps one of the more likely means of water contamination is in the disposal of unused herbicides or herbicide containers which are not thoroughly cleaned. Another means by which water can be contaminated is through lateral movement of the herbicide across the surface of the field in water or on soil being moved by water or wind. Still another means of contamination involves downward movement of herbicides through the soil to underground streams. The water so affected by all of these means of contamination includes that used for irrigation, recreation, drinking purposes, and natural streams which contain fish and serve as sources of water for wild and domestic animals.

The possibility of poisoning children, herbicide applicators, wild animals, or domestic animals directly with the herbicides used in cotton is less likely than with some other classes of pesticides. Nevertheless, many herbicides are toxic to animal life if sufficient internal or external contact occurs. Herbicides commonly used for control of weeds in fields are relatively safe once they have been applied in the fields, but exceptions to this can occur in the future. Perhaps one of the greatest dangers is in improper handling and storage of the herbicides before, during, and after application. Research and regulation to minimize such hazards are necessary.

The possibility that herbicides can cause mutagenic effects in all forms of plant and animal life exists, as it does for all classes of chemicals. The possibility of mutagenic effects is perhaps the least likely of all the hazards involved, but would be the most serious if it occurred. Research now being conducted under a Research and Marketing contract supervised by the USDA has failed to produce evidence that any one of more than 100 herbicides should be classed as mutagenic. The study, however, has not been completed, but the results thus far are encouraging. A continuing check on the possibility of mutagenicity, however, is mandatory if we are to properly discharge our responsibility for protecting consumers of agricultural products and the people who use the chemicals in producing crops.

2. Objective:

- a. To discover, characterize, and evaluate the significance of problems that may be created by weed control practices.
- b. To develop, where possible, methods and means of alleviating adverse side effects caused by the use of weed control methods.
- c. To develop safer alternative methods for use where significant adverse effects associated with any one method of controlling weeds cannot be resolved.

3. Research approaches:

- a. Conduct research to combine chemical applications into one operation and to increase the efficiency of various weed control operations, thereby reducing the number of operations involving machinery in any growing season. Much of this work would need to be done in cooperation with disciplines other than weed science. As each machine is assigned the task of doing more jobs simultaneously, it usually becomes heavier. Lighter construction and better load distribution are essential facets in keeping compaction of soil to minimum levels. The development and use of more effective herbicides having an effective life of 2 or 3 months should do much to reduce the necessity for multiple applications during the season.

- b. Develop more effective techniques for placing herbicides in soils and on plants. The effectiveness of herbicide treatments is tremendously influenced by the methods of placement in the soil or on plants. Only a minute fraction of the herbicide applied is actually needed at the site of action to produce the desired effects. Research to direct more of each application to the target site of action should permit us to reduce the amount of herbicides needed to obtain satisfactory control. Likewise, proper placement of herbicides can do much to prevent aerial drift and other movement of the material from the target area.
- c. Conduct research to discover new and more effective herbicides, and to improve the formulations of those which exist. The evaluation of new products and research to improve formulations continues to pay. From time to time, such advances as the discovery of the effect that surfactants have on increasing the contact action of herbicides, such as diuron, continue to illustrate the possibilities for improvements. In the case of diuron, the addition of surfactant permitted the same degree of phytotoxic action with 0.2 lb./A of the herbicide as compared with 1 lb./A in the absence of a surfactant.
- d. Conduct research to manipulate the persistence and movement of herbicides in soils, in plants, and in water. For any particular herbicide, our problem may be one of increasing the persistence long enough for the chemical to do its job, or it may be a problem of detoxifying the product after the job is finished. Most herbicides are subject to microbiological decomposition, and it is likely that experiments to increase or decrease the activity of microorganisms in soils and in water may provide a means of controlling persistence of herbicides. Entry and movement of herbicides in soils and in plants are often influenced by the formulation of the product, method of application, and time of application. Research to develop better techniques of application should do much to increase the effectiveness of herbicides being used, thereby decreasing the total amount needed to get the job done. Methods which appear promising for manipulating persistence include the addition of fertilizer elements to increase microbiological activity in soil, the addition of materials such as fungicides to decrease the activity of these organisms, and the use of special protective coatings on granular forms of herbicides which will delay or speed the initiation of attack by organisms in soil.

- e. Develop economical and practical filters that can be installed in drainage ditches or in streams, and develop settling or detoxification basins where herbicides entering water can be detoxified before massive introduction into unrestricted areas. Such an approach may or may not be practical, but it is logical that such approaches, in at least specialized circumstances, could be of major benefit in preventing major contamination of water supplies. For example, irrigation and drainage water from treated fields could be held in restricted ponds for periods of several days or weeks before permitting its return to unrestricted streams.
- f. Conduct research to determine and develop practical and economical methods of disposing of unwanted pesticides and used containers. Contract research for such purposes is now being negotiated, but even if it is successful, there will be a need for considerable followup research to implement application on a practical scale.

4. Character of potential benefits: Prevention of damage resulting from weed control methods to cotton production, other facets of agriculture, and to the general public.

L. Interactions of herbicides with insecticides, fungicides, nematocides, defoliants, fertilizers, and tailoring agents.

1. Situation: The possibility of interaction exists whenever more than one chemical is used in producing a crop. Such interaction can be beneficial, harmful, or neutral. For example, research in Maryland and in Mississippi shows that treatment of certain weeds with some herbicides predisposes the plants to increased injury from later applications of other herbicides. In Arizona, the mild toxic effect of one herbicide has been used experimentally to reduce the more drastic effect of a second herbicide on cotton. In this work, a relatively low rate of trifluralin inhibited lateral root development of cotton in the top two inches of soil. Lack of lateral roots, in the top two inches of soil, enabled the cotton to survive concentrations of diuron that would have been lethal to normal plants. Research in Texas and in Mississippi indicates that certain systemic insecticides, such as phorate or di-syston applied at planting can increase the phytotoxicity of diuron or monuron to cotton when the herbicides are applied preemergence. Limited research in Mississippi indicates that preemergence combinations of certain fungicides with some herbicides cause less injury to cotton under conditions favoring disease than does application of the herbicide alone.

While we cannot set, at this time, the average benefits and losses due to interactions of agricultural chemicals used in cotton production, we can predict some of the extremes. Increasing the susceptibility of certain weeds to one herbicide through pretreatment with another may mean that a currently resistant weed can be controlled. Chemicals which interact detrimentally can result in the complete loss of a stand. This is particularly likely to happen during the stand establishment part of the season. Perhaps only slightly less serious would be interactions between herbicides and other chemicals which would interfere with the normal growth and fruiting processes. Such interactions, being more subtle, would be more difficult to detect than those which eliminated stands.

Perhaps one of the greatest hazards, and one which has not been investigated extensively, is the possibility that one chemical may inhibit micro-organisms in the soil that detoxify other chemicals applied in producing the crop.

Interactions between agricultural chemicals that are known today have been discovered incidentally for the most part. Although we have suffered no major catastrophes from adverse interactions of chemicals, the vast number of combinations being used makes it advisable to start purposeful research to discover and characterize potentially hazardous combinations before widespread damage informs us of the hazard. Likewise, we have made little progress in utilizing beneficial interactions to our advantage in controlling difficult or resistant weeds. We can no longer afford the luxury of waiting for the windfalls of incidental observations.

An unknown but significant amount of research to characterize and identify the interactions of pesticides used in combination is being conducted by the agricultural experiment stations in most of the cotton producing states. Much of this research is basic in nature, as it should be, but we have need for closer liaison between this basic research and application to problems in production of cotton. Likewise, the USDA has laboratory teams located at Beltsville, Maryland, and at Fargo, North Dakota, who are investigating the interactions of pesticides as part of their activities in determining the fate of pesticides in soils and in plants. In connection with the activities of these two laboratories are two Research and Marketing contracts on the interactions of pesticides. These two contracts total \$140,000 and are to extend over a period of approximately 3 to 4 years. The money appropriated is to cover the entire period of the contracts. In addition to the basic research on interactions of pesticides in State Agricultural Experiment Stations from 0.3 to 0.5 scientific man-year per year is expended by State and Federal research workers in attempting to discover and characterize interactions of pesticides directly related to production of cotton. Activities by industry on this problem are not known quantitatively. However, most manufacturers of pesticides evaluate most of their products for compatibility with other pesticides.

2. Objective:

- a. Discover and characterize interactions between herbicides and other pesticides used in the production of cotton.
- b. In those instances where the discovered interactions are detrimental, develop alternative treatments which avoid the combinations giving adverse interactions, or develop means of eliminating the detrimental effect of the interactions when the chemicals are used in combination.
- c. In those instances where the discovered interactions present potential benefits, develop methods of utilizing the beneficial effects to improve the efficiency of controlling weeds in cotton.

3. Research approaches:

- a. Evaluate the response of cotton and pests which infest cotton to many different combinations of large groups, each of which contains several chemicals of the different classes of chemicals used in the production of cotton. Evaluation of all possible combinations of the chemicals used in the production of cotton would be a physical impossibility. The next best step, therefore, is to evaluate combinations involving groups of each class of pesticide rather than individual combinations. The purpose of such evaluations would be to eliminate those combinations having no effects, and to select, for further study, groups of combinations which have either beneficial or detrimental effects.
- b. When significant interactions between groups of different chemicals are detected, conduct investigations with smaller groups until the chemicals responsible for the interactions can be identified. When either beneficial or detrimental interactions have occurred, it should be possible to get leads on at least one of the chemicals from the response symptoms by either the crop or the pest. Further investigations with smaller groups should lead fairly directly to an identification of the responsible chemicals.
- c. When detrimental or beneficial interactions have been discovered, and the responsible chemicals are identified, conduct research to avoid or minimize the losses caused by the adverse interactions, and conduct research to find ways of utilizing the beneficial interactions. If certain herbicides interact with certain insecticides to produce detrimental effects, often it should be possible to select alternative combinations that exert no detrimental effects. In other instances, avoidance of the detrimental action may be obtainable by restricting the use of such combinations to dates of application in which environmental conditions

will be optimum for avoiding the adverse interaction. In other instances, basic information regarding the mode of action for beneficial interactions may facilitate the development of more effective control measures for resistant weeds.

4. Character of potential benefits: Avoiding losses in stands and yields and increasing our ability to control weeds effectively.

M. Methods and equipment for weed control.

1. Situation: Nearly all methods of weed control are presently limited by the equipment or procedures used in the practical application of the method. For example, when sprays are applied in fields of row crops, an estimated 10 percent of the spray is actually deposited on the target weeds. The remainder is wasted material and frequently is deposited where it is unwanted. The ability to conduct operations on a timely basis regardless of field conditions, improvements in the use of flame and cultivation to control weeds, and development of means of applying herbicides selectively are all needed urgently. The inadequacies of the equipment, or our understanding of the physical process involved in a particular control method, are both a cause of decreased effectiveness, increased cost, and undesirable side effects.

2. Objective: A more complete understanding of, and exploitation of, methods of applying herbicides and improved mechanical control of weeds.

3. Research approaches:

a. Possible control of weeds by solid stand (narrow row planting).

1. We will need to know the most desirable method of incorporating preemergence herbicide.
2. We will need to know some practical methods of postemergence application of chemicals. This might include specially coated granular materials and the best method of distributing them.
3. Determine if an economic total system can be proposed.

b. Possible control of weeds in row crops by the use of a broad spectrum fumigant or liquid spray drench closely surrounding the row drill.

1. We will need to develop a method of sealing gaseous fumigants into soil for a short while.
2. We will need to develop practical precision methods of injecting fumigant at high speed.

3. We will need to develop a high speed precision system for planting in a previously prepared narrow strip.
 4. We will need to determine if an economical system of using these methods can be devised.
- c. Season-long control of weeds through preplanting application of broad spectrum herbicides. For each chemical we will need to determine:
1. The method of application which yields best control (surface versus subsurface, liquid versus solid, quantity of carrier required, and small scale uniformity of application needed).
 2. Need to determine if overall system contains periods in which time is limited due to "bunching" of operations.
 3. Determine if chemical systems can be proposed for practical use.
- d. Control of weeds by unmanned automatically controlled field equipment.
1. Determine feasible mechanical control methods if labor requirement for operating equipment is not a factor.
 2. Determine reliability of the automatically controlled mechanical weed control equipment.
 3. Make estimates of cost, both operating and investment depreciations, of proposed unmanned systems.
 4. Determine if economic system can be proposed and integrated with other cultural practices.
4. Character of potential benefits: Same as other control benefits.

Recommended Research Effort, RPA 209

It is recommended that the total scientist man-year research effort (USDA, SAES, and industry) be as follows:

<u>Research Unit</u>	<u>Fiscal Year</u>			
	<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A	5.0	17.0	28.0	14.0
B	3.0	16.5	18.0	18.0
C	3.0	5.1	7.0	4.0
D	1.0	4.0	9.5	3.0
E	6.0	26.5	33.0	15.0
F	5.0	34.2	48.0	8.0
G	0.5	5.9	13.0	7.0
H	4.0	17.0	26.0	27.0
I	0.3	7.5	15.0	7.0
J	0.0	3.0	6.0	8.0
K	1.0	8.0	8.0	8.0
L	3.5	3.0	5.0	7.0
M	12.0	29.0	46.0	20.0
Total	44.3	176.7	262.5	146.0

In view of this total requirement, the recommended USDA and SAES research effort is shown in Table 10.

TABLE 10.--Scientist man-year requirements, RPA 209

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Johnsongrass control or eradication	USDA	1.4	2.0	5.0	2.0
	SAES	2.5	3.0	8.0	2.0
	Total	3.9	5.0	13.0	4.0
B. Nutsedge control or eradication	USDA	0.4	2.5	4.0	4.0
	SAES	2.0	3.5	4.0	4.0
	Total	2.4	6.0	8.0	8.0
C. Sida control	USDA	0.4	.9	1.0	1.0
	SAES	1.0	1.2	2.0	1.0
	Total	1.4	2.1	3.0	2.0
D. Cocklebur control or eradication	USDA	0.2	.6	2.0	0.5
	SAES	0.5	.9	3.0	0.5
	Total	0.7	1.5	5.0	1.0
E. Annual grasses and sedges control	USDA	0.6	3.0	3.0	2.0
	SAES	3.0	5.0	5.0	3.0
	Total	3.6	8.0	8.0	5.0
F. Annual broadleaf weeds control	USDA	0.3	3.5	6.0	2.0
	SAES	2.8	7.5	12.0	1.0
	Total	3.1	11.0	18.0	3.0
G. Bermudagrass control	USDA	0.1	0.4	1.0	1.0
	SAES	0.3	2.5	2.0	1.0
	Total	0.4	2.9	3.0	2.0
H. Perennial broadleaf weeds control or eradication	USDA	0.3	2.5	4.0	3.0
	SAES	1.8	5.0	7.0	4.0
	Total	2.1	7.5	11.0	7.0

(continued)

TABLE 10.--Scientist man-year requirements, RPA 209 (continued)

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
I. Winter weeds control or eradication	USDA	0.1	1.5	2.0	1.0
	SAES	0.1	2.0	3.0	1.0
	Total	0.2	3.5	5.0	2.0
J. Biological control of individual weed species	USDA	0.0	2.0	4.0	4.0
	SAES	0.0	1.0	2.0	4.0
	Total	0.0	3.0	6.0	8.0
K. Problems created by weed control measures	USDA	0.2	2.0	2.0	2.0
	SAES	0.3	3.0	3.0	3.0
	Total	0.5	5.0	5.0	5.0
L. Interactions of herbicides with insecticides, fungicides, nematocides, defoliant, fertilizers, and tailoring agents	USDA	0.3	0.6	1.0	2.0
	SAES	0.2	0.4	2.0	3.0
	Total	0.5	1.0	3.0	5.0
M. Methods and equipment for weed control	USDA	1.2	3.0	4.0	4.0
	SAES	2.2	6.0	12.0	6.0
	Total	3.4	9.0	16.0	10.0
RPA 209 Total	USDA	5.5	24.5	39.0	28.5
	SAES	16.7	41.0	65.0	33.5
	Total	22.2	65.5	104.0	62.0

Facility Needs to Support the Recommended Research Effort, RPA 209

Facilities for increasing cotton research should not be concentrated at a single location. Because of the different weed-environmental conditions, facilities should be distributed in the general areas where the problem occurs. Since the U. S. Department of Agriculture and the various State experiment stations are already working on most all of these problems to some degree, funds directed to upgrading the facilities at selected locations would be the most valuable toward getting an early solution of the problem. If it is assumed that the facility requirements are approximately \$50,000 per man, the sum of approximately \$4 million will be required to provide the additional facilities for both State and Federal operations.

Research Problem Area 307 - Improvement of Biological Efficiency of Field Crops

Situation

Improvement of the economic position of the cotton producing industry in the United States depends on increasing the biological efficiency of the cotton plant. Improvements can be accomplished by: (1) full utilization of the current germ plasm that is derived from wild and cultivated sources, (2) research findings of biochemical investigations leading to the knowledge of how to modify the cotton plant for more efficient production with better adaptation to the varying range of soil and climatic conditions, and (3) development of genetic materials or other methods to provide high levels of resistance to insects, diseases, and other plant pests. In the past 25 years, great progress has been made in the development of varieties fairly well adapted to mechanical production and to machine harvesting. Even so, current production efficiencies are far from being adequate at the present time. The development of better adapted varieties and better methods will lead to the required greater efficiency in production consistent with improved yield and quality.

The Western States have come closer than other areas to meeting requirements of present-day textile processing practices with varieties of high tensile strength, adequate fiber length, and fineness characteristics in combinations required by the rapid, automated needs of modern textile mills. Continuing pressures for still further improvements in raw fiber properties will undoubtedly be accelerated in the future. Therefore, there is a continuing need for cottons from all of the producing areas with longer fiber, greater tensile strength, uniformity of fiber length, and fineness in those combinations required by the mills, which will at the same time have high yielding capacities and are adapted to varying environmental conditions. This will result in optimum yields of the quality fiber that will make cotton highly competitive with man-made fibers and at the same time give the producer proper returns for his efforts.

Specific Research Units, RPA 307

A. Improved combinations of yield and high quality fiber.

1. Situation: Modern textile processing methods impose a continuously increasing demand on improved physical properties of raw textile fibers. At the same time, the rising costs of production necessitate increasing yields per given unit of land. While Western Acalas have given good yields with high fiber quality, the remainder of the Cotton Belt has not had such combinations available. Separate germ plasm exists for high

quality characteristics and high yield potentials. However, efforts to combine both have met with limited success. Further knowledge of the factors controlling flowering and fruiting and the potential for modification by chemical or other means would offer promise toward further advances. Improvements of this nature would be reflected by lowered costs of processing and production and would make cotton more competitive with man-made fibers.

2. Objective: Develop varieties and methods for improving combinations of yield and fiber quality required to satisfy advancing textile technology and consumer acceptance, resulting in a more competitive position for the industry which will lead to expanded markets.

3. Research approaches:

- a. Collect and evaluate all potentially useful germ plasm.
- b. Improve breeding methodology through cytogenetic manipulation and transfer of useful traits to cultivated varieties.
- c. Conduct inheritance studies of natural and induced mutations and quantitatively inherited traits.
- d. Breed for recombinations of the components of high yield and high quality integrated with pest resistance and agronomic properties for economic production.
- e. Obtain valid estimates of agronomic, fiber, and spinning properties through performance testing of experimental strains and commercial varieties.
- f. Determine the biochemical and physiological processes controlling flowering and fruiting and the extent and nature of the variability in the genus.
- g. Develop chemical and other methods for enhancing plant performance.
- h. Conduct biochemical and physiological studies on fiber and seed development and the factors limiting production and quality.

4. Character of potential benefits: Improved net profits to producers and consumer acceptability and demand.

B. Improved cultural practices.

1. Situation: Every crop year, environmental stresses of varying severity and type are imposed on the growing crop. These may result from such things as water deficiencies or excesses, temperature extremes, changes in incident light level and quality, and wind. Within certain limits, proper selection of varieties and cultural practices can offset the adverse effects of such environmental extremes. To do this, however, there is need for an understanding of the kinds and magnitude of the effects of such stresses on the life processes of the plant and for the extent of variability of response existing within the available cotton germ plasm. The availability of such information would provide the means whereby plant tailoring techniques, specific varietal characteristics, and elements of microclimate or ecological control could be combined to at least, in part, offset the adverse effects of the climatic stresses which are imposed annually.

2. Objective: To obtain, through breeding and the development of new methods, more efficient cultural practices which will result in the minimization of the effects of climatic stress and a crop better adapted to mechanized production.

3. Research approaches:

- a. Evaluate germ plasm for plant characters to improve the adaptability to environment and mechanized production practices.
- b. Breed for varieties more highly specialized for mechanical production.
- c. Conduct studies on the effect of environmental factors on plant processes (photosynthesis, transpiration, transport, respiration, metabolism, nutrition, etc.) to furnish basic information needed for more efficient production.
- d. Develop methods for increasing the efficient use of environment for producing plants better adapted to mechanical production practices.
- e. Determine effects of agricultural chemicals and combinations on plant growth.

4. Character of potential benefits: Reduce production costs and improve plant efficiency.

C. Improved pest resistance.

1. Situation: Cotton diseases, insects, and nematodes continue to cause heavy losses in yield and quality and further complicate production practices. Their present control represents a major item in the cost of producing a crop. High levels of tolerance to certain pests are known to be present in cotton germ plasm. The utilization of these genetic characteristics have in isolated instances provided resistance to certain pests in current varieties. When high levels of tolerance are known to exist in the genus, a continuing effort is required to introduce them into future varieties. Where lower levels of tolerance are known, effort is required to collect information on the precise nature of the tolerance mechanism. Where none exists, other biological methods for protection must be developed.

2. Objective: Develop varietal resistance and other methods to minimize losses from cotton pests.

3. Research approaches:

- a. Evaluate germ plasm for sources of resistance to diseases, insects, and nematodes.
- b. Conduct studies on the nature of and the mode of inheritance of pest resistance factors and the correlated responses of resistant factors with other agronomic and fiber properties.
- c. Develop phytobiological methods for control of pests.
- d. Improve methods for measuring degrees of resistance to pests.
- e. Develop breeding lines with combinations of pest resistant factors.
- f. Breed for the combination of pest resistant factors with yield and fiber quality components.

4. Character of potential benefits: Reduced losses from pests and from control costs and improved quality.

D. Improved harvesting characteristics.

1. Situation: The harvesting of cotton has changed from hand picking to predominantly machine harvesting in the past 25 years. The industry is rapidly approaching the point where all cotton will be machine harvested. Excessive vegetative growth, lodging, plant trash, late maturity, and field weathering all lower machine harvesting efficiency, yields, and crop quality.

Harvest efficiency has been improved by the use of harvest aid chemicals, by breeding storm resistant, early maturing varieties and by engineering developments in harvesting machines. Further advances are urgently required and can be made through genetic and physiological control of fruiting, plant height and plant growth patterns, by development of more dependable harvest-aid techniques, by modifying boll types for greater harvesting efficiency, and by improving the design and operation of harvesting practices.

2. Objective: To develop methods and varieties designed for maximum efficiency of mechanical harvesting and to preserve inherent quality and yield.

3. Research approaches:

- a. Conduct studies on the physiology and biochemistry of abscission to furnish basis for improvement of techniques for defoliation.
- b. Develop new chemicals and new techniques for preparing field for mechanical harvesting.
- c. Develop improved methods for preserving inherent quality and yield prior to harvest.
- d. Breed for varieties with stormproof bolls for stripper harvest and storm-resistant bolls for spindle machine harvest.
- e. Breed for varieties with early maturity, compact plants, and fruiting heights suitable for machine harvest.

4. Character of potential benefits: Improved harvesting efficiency and preservation of inheritant fiber quality.

E. Improved cottonseed quality.

1. Situation: Cottonseed is a valuable source of oil and a potentially valuable source of protein for human consumption and for animal production. The factor limiting cottonseed's usefulness in the latter two categories is the presence of gossypol which is not readily separated from the non-oil components. Recent isolation and incorporation into upland type cottons of the glandless character has opened the possibility of producing gossypol-free cottonseed meal at low cost. In the past little attention has been given to improving oil content and no efforts have been made to search the cotton germ plasm for improved protein. Significant improvements have been made in other oil and protein crops and make it likely that similar improvements can be accomplished in cottonseed. Such accomplishments would provide expanded markets for this part of the cotton crop and materially add to the world source of available protein for both man and animal.

2. Objective: Improvement of quality and quantity of cottonseed products for human and animal consumption.

3. Research approaches:

- a. Evaluate germ plasm for increased quality and quantity of oil and protein and for reduced gossypol content.
- b. Conduct studies on the biosynthetic pathways of cottonseed products and search for means of increasing their quality and efficiency of production.
- c. Develop methods and breeding lines for production of higher quality cottonseed with respect to oil and protein.
- d. Combine high seed quality characteristics with those combinations producing high yields and high quality fiber.

4. Character of potential benefits: New source of food protein, improved oil quality resulting in expanded markets.

Recommended Research Effort, RPA 307

TABLE 11.--Scientist man-year research requirements, RPA 307

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Improved combinations of yield and high quality fiber components	USDA	10.4	25.9	27.9	31.9
	SAES	29.8	42.7	50.7	58.7
	Total	40.2	68.6	78.6	90.6
B. Improved cultural practices	USDA	7.5	18.7	20.7	24.7
	SAES	19.7	28.2	37.2	47.2
	Total	27.2	46.9	57.9	71.9
C. Improved pest resistance	USDA	2.5	6.3	11.3	14.3
	SAES	8.8	12.6	19.6	27.6
	Total	11.3	18.9	30.9	41.9
D. Improved harvesting characteristics	USDA	3.4	8.4	10.4	12.4
	SAES	8.7	12.5	17.5	23.5
	Total	12.1	20.9	27.9	35.9
E. Improved cottonseed quality	USDA	1.9	4.7	8.7	10.7
	SAES	6.1	8.7	13.7	20.7
	Total	8.0	13.4	22.4	31.4
RPA 307 Total	USDA	25.7	64.0	79.0	94.0
	SAES	73.1	104.7	138.7	177.7
	Total	98.8	168.7	217.7	271.7

Facility Needs to Support the Recommended Research Effort, RPA 307

Implementation of the recommended research requires the development of a major Federal facility and State facilities to accommodate the projected increase of research personnel. The major facility would be used to accommodate a part of the projected 53 Federal SMY's and the cost would be approximately \$1,000,000. The remainder of the 53 SMY's would be housed in existing facilities, primarily USDA. State facility requirements would cost approximately \$2,225,000. These would accommodate 104 SMY's as projected by the recommendations.

These facilities would be used for housing the expanded programs projected herein for the improvement of the biological efficiency of cotton.

Research Problem Area 308 - Mechanization of Production of Field Crops

Situation

In the period since World War II the man hours required to produce a bale of cotton have been reduced from more than 150 to approximately 30. Even with this reduction in labor, overall production costs have continued to soar due to higher initial and operating costs of machinery, increased wage rates, and higher field losses from pests and inefficient machine operations. Further, competition with man-made fibers has exerted pressure on all segments of the industry to produce a cleaner, cheaper fiber with a substantially improved end-use value. Although great strides have been made in the design of all machinery for cotton production and ginning, continued pressure must be exerted to develop more efficient methods and equipment to reduce losses, to better utilize available labor, and to preserve the inherent quality of the fiber.

Equipment is now available that will combine a number of field operations. For instance, with one-machine operation the field can be bedded and the fertilizer placed for planting. Another single operation combines planting and the placement of pre- and postemergence chemicals. The necessity for intensive tillage operations has been obviated through improved use of pest controls. Chemicals are applied by ground equipment and airplanes.

Although more than 90 percent of the crop is presently harvested by machines, there are still opportunities for reducing costs. Harvesting losses of 20 to 30 percent are unusual with present spindle pickers.

The purchase price is high; the machines are heavy and cumbersome; and dependable operators, who can maintain the equipment and prevent excessive field losses, are in short supply and need continuous supervision.

To those who have made a thorough analysis of all the cotton production phases, few areas stand out for reducing costs more than the inefficient handling and pre-ginning storage methods now in use. Harvesters spend a large portion of their potential operating time dumping loads into transport units that require extra labor at the turnrow for this operation. Further, field conveyances, such as trailers, make high-priced storage units, take up valuable space on the gin yards, and require extra men and power units for placing them where they can be unloaded when the gin is ready to receive the seed cotton.

Modern gins costing a quarter of a million dollars and having from 750 to 1,000 hp. connected load are not uncommon in the intensive cotton producing areas. Although much of the equipment has been automated, a surplus of manpower is still in evidence. Contributing to ginning costs is the large amount of trash that must be handled with present harvesting systems. Much more stringent regulations dealing with the disposal of trash and the control of dust and "fly" are being enacted by the Federal Government, States, and municipalities.

The inefficient system for packaging and sampling is a chapter in tradition that can only be resolved by progressive minded industry with the conscientious objective of preserving a place for cotton fiber in the lives of people and industry of tomorrow. Some of the equipment and methods for improving the situation are presently available; however, little interest in further developments can be expected until the demands of the industry change.

Specific Research Units, RPA 308

A. Planting, fertilizing, and tillage (mechanization of production).

1. Situation: The high cost of planting, fertilizing, tilling, combined with the damage done to the soil structure due to frequent trips through the field with heavy machinery, has focused attention on the need for new methods and machinery systems which will reduce mechanical operations, afford more precise placement, and leave the row in suitable shape for the mechanical harvester.

Feasibility studies are presently underway at Stoneville, Mississippi, and Shafter, California, for investigating some problems of minimum tillage. There is need for continuous reappraisal of plant population needs throughout the Belt depending on weather conditions, the fertility of the soil, varieties of cotton grown, and methods of harvest.

2. Objective: Development of equipment and techniques to obtain and maintain an adequate plant growth at reduced cost.

3. Research approaches:

- a. Obtain increased knowledge of what environment the cottonseed needs.
- b. Determine what environment actually exists in soils under given cultural treatments and weather regimes.
- c. Determine techniques to correct the environment where it is found to be inadequate.

- d. Develop equipment and systems for employment under various environmental conditions that will provide desirable growth conditions with a minimum amount of equipment and trips over the field.

4. Character of potential benefits: Reduced costs and increased production.

B. Pest control--weeds, insects, and diseases (mechanization of production).

1. Situation: With reduced manpower available and the need for decreasing the amount of trips through the field with machinery, the incidence of weeds and insects will increase without improved equipment for placing chemicals to control these pests. Spray equipment will have to be better designed to meet the needs of the crop and smaller quantities of material will need to be applied. This situation is particularly acute in rain-grown areas and in those areas where minimum tillage practices are being introduced. Better control of chemicals applied to the plant in order to avoid drifting to other crops in nearby fields has long been recognized as a need of the industry. At the present time light traps are being used to monitor for certain harmful insects; however, the prospect of control by these methods appears brighter in recent years.

2. Objective: To investigate methods and equipment to control weeds, insects, and diseases at a lower cost and with less residual chemical contamination to the soil and to integrate these functions into improved cotton production systems.

3. Research approaches:

- a. Investigate methods which will reduce the amount of liquid or dust chemicals (active ingredients) needed for control.
- b. Investigate other less common forms of chemicals such as gases, systemics, and granules that can be applied with greater precision (rate and placement).
- c. Develop complementary pest control methods and equipment and integrate these functions into improved production systems.

4. Character of potential benefits: Reduce losses caused by pests and control costs of application.

C. Harvesting (mechanization of production).

1. Situation: The cost of harvesting has been materially reduced in recent years through the use of mechanical equipment. It has been estimated that about 80 to 85 percent of all the acreage grown in the United States is mechanically harvested. Losses are still excessive, running from 20 to 25 percent in some fields. Initial harvesting machinery costs are high as are the upkeep costs. It was recognized that the quality of both lint and seed is still somewhat lower than cotton picked by hand and a good bit more trash and moisture are harvested with the cotton than is desired. The application of harvest-aid chemicals is costly and unreliable depending to a large degree upon weather conditions. Results are often less than desired. Efforts are being made to selectively defoliate the lower portion of the plant for early season picking.

2. Objective: Development of equipment and methods for reducing the losses and cost incurred during harvesting while maintaining the quality of seed cotton.

3. Research approaches:

- a. Determine plant and machine functional relationships that affect harvesting efficiency and trash contaminants in both picker and stripper-type harvesters. Develop improvements in harvesting equipment.
- b. Correlate harvester performance and physical characteristics of cotton plants and cooperate with cotton breeders in plant-type development.
- c. Optimize the relationship between cultural practice systems and harvesting and handling systems.
- d. Cooperate with other disciplines and with industry in evaluating the effects of new harvest-aid materials and new machine developments on harvesting efficiency and cotton quality.

4. Character of potential benefits: Reduce losses and control costs.

D. Handling, transportation, and storage (mechanization of production).

1. Situation: The cost of handling, transportation, and storage is closely related to all other items in this problem area and is important, not only from the standpoint of the actual monetary expense but also from the cumulative quality reduction of both lint and cottonseed. The need for improved handling and storage systems for seed cotton is being felt throughout the industry because of the high cost factors brought about by inefficient use of harvester operating time and peak demands on transportation facilities that are being used for temporary storage. Research has indicated that some cleaning, drying, and storage of seed cotton may be beneficial prior to gin house operations.

2. Objective: Development of improved field handling, transportation, and preginning storage systems for seed cotton that will preserve quality and reduce costs.

3. Research approaches:

- a. Investigate alternative means, such as by pneumatic or mechanical lift methods, for moving seed cotton at the field level so as to reduce time and labor requirements.
- b. Investigate feasibility of reducing seed cotton bulk density during harvesting or field handling operation in order to reduce transportation costs and for use in preginning storage when desired.
- c. Determine influence of various storage procedures and conditions on all fiber properties. Develop methods for cottonseed storage that will have minimum deleterious effect on fiber properties.

4. Character of potential benefits: To reduce costs and maintain quality.

E. Ginning (mechanization of production).

1. Situation: Recent studies have shown that the cost of ginning now exceeds the cost of harvesting. Further, more complaints, either justly or unjustly, are leveled at the ginner by both the producer and the spinner than any other segment of the industry. The services offered by the ginner fixes the ultimate price the producer can receive for his product. The demands for faster ginning brought on by mechanical harvesters have forced the gins to become more expensive and sophisticated without a corresponding return on owner investment. In cleaning and separating the fiber from the seed, the product is subjected to harsh machine actions that break and otherwise damage both the fiber and seed which reflect on the product quality.

2. Objective: Improvement of equipment and methods for preserving the inherent fiber quality of cotton during ginning and for reducing the cost of the overall ginning process.

3. Research approaches:

- a. Study the interrelated effects of varietal characteristics and production practices on ginning performance; and investigate the relationships among the various components, forces, and actions within the ginstand in order to effect improvements which will better preserve fiber quality.
- b. Develop and/or improve cotton conditioning and cleaning equipment which will better preserve the use value of cotton.
- c. Develop foreign matter collection and disposal systems to reduce air pollution around the gin.
- d. Develop materials handling systems for gins which will allow the material to be handled at less cost.
- e. Develop a packaging system which will handle cotton at a rate upwards of 30 bales per hour.

4. Character of potential benefits: Reduce costs.

F. Crop-climate relationships (mechanization of production).

1. Situation: Cotton crop stands are uncertain due to weather and soil conditions. More needs to be known about seed environment requirements as related to proper stands, taking into consideration types of soils and cultural practices. The quality of lint and seed is related to the proper use of preharvest chemicals (defoliant and desiccants) particularly in heavy cotton growths. It is thought that some improvement in quality, probably at the expense of yield, could be realized by limiting fruiting and maturing periods.

2. Objective: A more complete understanding of the factors affecting, and exploitation of methods for controlling, cotton fruiting and maturity periods in order to maintain fiber quality and to reduce cost of harvesting.

3. Research approaches:

- a. Study those growth and maturity factors which influence defoliation in order to provide a more precise guide for bringing the plant to an ideal condition for defoliation at the time desired.
- b. Expand knowledge of the effect of even stands, even rates of growth and fruiting, and vegetative cutout on defoliability.
- c. Investigate economics of controlling fruiting as it affects yield and quality.
- d. Develop improved methods and equipment for more precise application of harvest-aid chemicals.
- e. Investigate other means, such as heat for defoliation, desiccation, or wilting.

4. Character of potential benefits: To reduce costs.

Recommended Research Effort, RPA 308

TABLE 12.--Scientist man-year research requirements, RPA 308

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Planting, fertilizing, and tillage (mechanization of production)	USDA	3.1	5	7	10
	SAES	3.7	6	8	12
	Total	6.8	11	15	22
B. Pest control--weeds, insects, and diseases--(mechanization of production)	USDA	5.0	8	9	12
	SAES	5.6	9	12	16
	Total	10.6	17	21	28
C. Harvesting (mechanization of production)	USDA	3.1	5	7	11
	SAES	3.7	6	7	10
	Total	6.8	11	14	21
D. Handling, transportation, and storage (mechanization of production)	USDA	1.3	2	4	6
	SAES	3.1	5	8	10
	Total	4.4	7	12	16
E. Ginning (mechanization of production)	USDA	4.4	7	8	11
	SAES	0.6	1	1	2
	Total	5.0	8	9	13
F. Crop-climate relationships (mechanization of production)	USDA	2.5	4	5	6
	SAES	2.5	4	5	6
	Total	5.0	8	10	12
RPA 308 Total	USDA	19.4	31	40	56
	SAES	19.2	31	41	56
	Total	38.6	62	81	112

Facility Needs to Support the Recommended Research Effort, RPA 308

An increase of 73.4 SMY is recommended by the Task Force for 1977 over the 1966 figure. Based on a figure of \$60,000 per SMY, there would be a need for approximately \$4,404,000 to construct additional facilities.

These facilities would jointly house the 73.4 scientists and engineers. Approximately equal numbers would be State and Federal.

Research Problem Area 309 - Systems Analysis in Production of Field Crops

Situation

The need for increased production efficiency and thereby lowered production costs in cotton is quite evident. Increased efficiency and lower costs would improve cotton's competitive position both at home and abroad. During recent years, the expansion of production in man-made fibers and increases in the production of foreign growths of cotton have made serious inroads in the use of U. S. cotton.

Because of the wide scope of inquiry in subject matter fields, research is, of necessity, conducted and reported by specialists within each of these fields. This means that new techniques growing out of research usually are not appraised in terms of their interrelationships with other practices in the production system. It is necessary to fit these pieces into a sound and efficient production system. This can involve selection of a variety, choice of a practice or machine, or the proper combination of crop and livestock enterprises. Often a practice or machine which appears outstanding when evaluated on its individual merit will be found to have shortcomings when fitted into a system.

Research approaches to this problem can be made in a number of ways, all of which are more or less interrelated.

Specific Research Units, RPA 309

A. Evaluations of emerging technology.

1. Situation: As a result of expanded research programs, new production techniques continue to become available for consideration as a part of production systems for cotton. Because of the number of these innovations and, in many cases, the sizable investment associated with them, they need to be evaluated in terms of their economic feasibility early in their development and introduction on farms. Such an evaluation would keep farms from having to appraise these techniques on a costly trial-and-error basis.

2. Objective: Objectives of this study would be specifically: 1) To develop data on physical inputs and outputs, and costs and returns associated with important new technological developments when they first appear; 2) to appraise the effect of selected new techniques on production costs and economic efficiency; and 3) to evaluate the effects of new techniques on the organization of farms of different sizes.

3. Research approaches: The conduct of these studies will relate specifically to the resource requirements, costs, and yields associated with various crop practices such as new varieties; alternative methods of weed control, including chemicals; alternative methods of controlling insects; use of airplanes; skip-row planting of cotton; and alternative methods of harvesting, including custom operations. These studies will involve combined efforts of economists and physical and biological scientists from various disciplines. Budgeting and activity analysis will be used in an economic evaluation of these practices on representative farms to determine the probable impact of their use on the organization and operation of farms.

4. Character of potential benefits: Improved production efficiency and lowered production costs.

B. Labor efficiency.

1. Situation: Cotton production has a long history of intensive labor use. It is only since World War II that drastic reductions in the use of labor have been made in the production of this crop. In 1940-44, it took 182 man-hours of labor to produce a bale of cotton. By 1961-65, labor requirements had been reduced to 43 man-hours per bale. Recently passed minimum wage legislation is likely to press producers even more in the direction of improved labor efficiency. This, plus the need to improve incomes of farm labor in the South, points up the need for further research in the area of efficient use of labor.

Reducing labor requirements, in addition to implying better use of labor, introduces the corollary concept of adopting more technology. For example, farmers are cutting labor costs by shifting from 4-row to 6- and 8-row planting and cultivating equipment, by shifting from 1- to 2-row harvesters, and by employing chemical and mechanical weed control measures.

The recently passed minimum wage legislation will support the prospective long-run rise in the prices of labor. At the same time, further adoption of new technology in the cotton production process will require workers of increasingly greater skill. It is imperative that cotton producers be able to attract and retain workers of high quality if production efficiency is to be increased and costs of production lowered.

2. Objective: Objectives of this study would be: 1) To determine segments of the production systems which make the most efficient use of labor; 2) to determine the economic feasibility of using larger production equipment and other technology and the effect of such use on labor requirements; 3) to determine economic feasibility and the impact on production systems and farm organization of alternative high-wage labor systems, including major dependence on regular hired labor paid annual salaries; and 4) to determine the effects of improved labor efficiency on returns to labor and to management.

3. Research approaches:

- a. Evaluating segments of the production system which appear to offer possibilities for reducing labor needs under controlled experimental conditions.
- b. Analyzing production systems on selected representative farms which are now undergoing the transition from labor-intensive to labor-extensive techniques and methods.

4. Character of potential benefits: Improved labor efficiency and increased incomes to labor and producers.

C. Regional analysis of cost of production.

1. Situation: Since 1964, the Economic Research Service has been engaged in determining the annual costs of growing cotton by regions in the United States. A part of this job is to develop annual estimates of regional and national inputs and the effect of changes in inputs, prices, and yields on production costs. Results of the 1964 study show that labor and power and equipment costs accounted for 24 percent and 19 percent, respectively, of the total costs of growing cotton.

2. Objective: Specific objectives are: 1) To determine adjustments in production systems for growing cotton that would lead to cost reductions, and 2) to determine those cost areas that offer the greatest potential for cost reduction through further research.

3. Research approaches:

- a. It is proposed that these data be further analyzed to determine which areas of costs or items of production offer the greatest potential for reducing the cost of growing cotton. This can be approached in two ways: 1) inter-farm and interregional comparisons can be made in an attempt to account for variations in cost associated with individual segments of production, and 2) those cost areas or items which offer the greatest potentials for reducing costs through further research by other disciplines can be determined.
- b. In addition, field studies at selected locations would use the survey approach to study production systems on low-cost, efficiently operated farms to determine how these conditions are attained.

4. Character of potential benefits: Reduced production costs.

D. Adjustments in cotton production.

1. Situation: To properly evaluate the economic potential of a crop or livestock enterprise without considering it as a part of the total farm organization is extremely difficult. Enterprise evaluations per se are useful for certain purposes, but an enterprise cannot be completely and properly evaluated until it is fitted into a production organization. This is occasioned by the fact that certain complementary and supplementary relationships exist between enterprises and the way they fit into an organization has a decided influence on the efficiency with which labor, machinery, capital, and other production resources can be used. Balanced enterprise combinations should lead to more efficient use of all production resources, and insofar as they do, they lead to hidden economies in the production of specific crops such as cotton.

In addition, increased efficiency may be attained by effecting adjustments among farms and among regions. A recent study in South Carolina indicates that the sale and transfer of cotton allotments from less efficient to more efficient farms can result in an economic advantage for both seller and buyer. Similar increases in efficiency can be attained by shifting production from one region to another.

2. Objective: Specific objectives of this study would be: 1) To determine the most efficient combinations of enterprises on cotton farms, especially as they are affected by size of operation and level of technology; 2) to indicate how increased efficiency may be attained by adjustments among farms; and 3) to determine potential increases in efficiency by adjustments among areas of production.

3. Research approaches:

- a. Production coefficients will be derived by production regions for farms of different sizes and with different soil resources and using different levels of technology.
- b. Using these coefficients and a linear programming technique, computers will be utilized to determine optimum organizations for maximum revenues under each of the conditions described above.
- c. Considering these results, opportunities for adjustments among farms and among regions will be analyzed.

4. Character of potential benefits: Reduced cotton production costs and improved total farm incomes.

E. Machine systems (systems analysis for optimum return).

1. Situation: Farm managers must often choose from among a number of possible alternatives in order to select the proper sequence of operation, sizes, and types of machinery to be used, operations to be performed, as well as other factors in the planning for each crop to be produced. Plans must be flexible in order to cope with the changes brought by weather, insects, disease, or some other eventuality. More and better data are needed on the variables that may be encountered so that this information can be fed into computers, the results of which are to be used in determining choices that can be made. As the size of the farming units increases, such information becomes even more important.

2. Objective: Development of a synthesis of machine systems used in cotton production in order to provide an analysis of alternatives leading to reduced cost, machinery requirements, and labor inputs.

3. Research approaches:

- a. Obtain more complete and necessary data on the influence of each alternate or substitute production practice on yield, quality, operating schedules, workloads, and net returns.
- b. Develop reliable numerical values to express true functions of the various entities.
- c. Develop cost of use of machinery required for each alternate cultural practice and subsystem.
- d. Develop suitable mathematical models of production systems for various cotton production areas.

4. Character of potential benefits: Planning is systemized so that men, money, and materials can be scheduled for the sequence of operations.

Recommended Research Effort, RPA 309

TABLE 13.--Scientist man-year research requirements, RPA 309

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Evaluations of emerging technology	USDA	0.0	1.0	3.0	4.0
	SAES	0.0	1.0	1.0	2.0
	Total	0.0	2.0	4.0	6.0
B. Labor efficiency	USDA	0.0	2.0	4.0	4.0
	SAES	0.0	1.0	2.0	2.0
	Total	0.0	3.0	6.0	6.0
C. Regional analysis of cost of production	USDA	0.0	7.0	7.0	7.0
	SAES	0.0	2.0	2.0	2.0
	Total	0.0	9.0	9.0	9.0
D. Adjustments in cotton production	USDA	0.0	12.0	15.0	15.0
	SAES	1.2	8.0	10.0	10.0
	Total	1.2	20.0	25.0	25.0
E. Machine systems (systems analysis for optimum return)	USDA	0.0	1.0	2.0	3.0
	SAES	1.0	7.0	7.0	8.0
	Total	1.0	8.0	9.0	11.0
RPA 309 Total	USDA	0.0	23.0	31.0	33.0
	SAES	2.2	19.0	22.0	24.0
	Total	2.2	42.0	53.0	57.0

Facility Needs to Support the Recommended Research Effort, RPA 309

Additional facilities needed to implement this research program would consist primarily of office space for scientists and aids. The addition of 55 scientists at \$6,000 per man would indicate a need for \$330,000 for facilities.

Research Problem Area 405 - Production of Field Crops with Improved
Consumer Acceptability

Situation

The fiber properties of cotton influence the efficiency of processing in textile mills and the acceptability of finished goods. The fiber properties of cotton are influenced by several factors before they are marketed. These include the inherent potential of the seed planted, the growing conditions in a broad sense (soils, water, cultural practices, weather, insects, diseases, weeds, and harvest-aid chemicals), field deterioration, and harvesting and ginning practices. Further, much of the cotton now produced in the United States does not have fiber properties that adequately meet modern textile mill requirements. Knowledge of the factors affecting fiber quality is needed to improve as well as to preserve the characteristics for consumer acceptability from the processors' and ultimate consumers' points of view.

Specific Research Units, RPA 405

A. Production of cotton with improved fiber properties for greater consumer acceptability.

1. Situation: Currently, the bulk of the cotton produced does not have fiber properties required by the textile mills to meet the demands of modern textile technology. There is a distinct need for expansion of research effort to evaluate the products of the national cotton improvement program.

2. Objective: Evaluate the causes of variability in fiber and spinning performance of cotton strains and varieties.

3. Research approaches:

- a. Study effects of enzymes and microorganisms on fiber deterioration in the field.
- b. Conduct studies on the influence of genetic factors and environmental conditions on fiber and spinning performance.
- c. Conduct studies on influence of harvesting and ginning procedures on fiber and spinning performance.
- d. Develop improved techniques and instrumentation for measuring variation in fiber and spinning properties of cotton as influenced by the above causes.

4. Character of potential benefits: Improved consumer demand and better competitive position in domestic and world markets.

B. Quality preservation during the harvesting and ginning operations (production for improved consumer acceptability).

1. Situation: It has been illustrated that no mechanical manipulation of cotton, either in the form of seed cotton or lint, from harvesting through ginning improves the quality. To the contrary, each action or process degrades the quality of the product to some extent. The cumulative degrading effects start when the spindle touches the seed cotton and continues through conveying, wagon storage, drying, cleaning, ginning, lint cleaning, and packaging. It is important that factors affecting the quality at each stage be identified and controlled if a product of suitable end-use value is delivered by the producer to his customer. The same can be said of the cottonseed. However, in this case the standards are not as high and except for planting seed, the damage is not as critical or costly to the producer or processor.

2. Objective: To maintain inherent quality of fiber and seed.

3. Research approaches:

- a. What handling operations can be reduced or eliminated?
- b. What steps can be taken to eliminate or further minimize trash and moisture at the harvesting stage?
- c. Can less harsh methods of separation of the seed from the lint and subsequent lint cleaning be devised?

4. Character of potential benefits: Mechanical damage will be minimized resulting in a product with better end-use value.

Recommended Research Effort, RPA 405

TABLE 14.--Scientist man-year research requirements, RPA 405

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Production of cotton with improved fiber properties for greater consumer acceptability	USDA	7.3	11.0	15.0	20.0
	SAES	5.3	8.0	11.0	15.0
	Total	12.6	19.0	26.0	35.0
B. Quality preservation during the harvesting and ginning operations (production for improved consumer acceptability)	USDA	2.0	3.0	5.0	8.0
	SAES	0.0	0.0	0.0	1.0
	Total	2.0	3.0	5.0	9.0
RPA 405 Total	USDA	9.3	14.0	20.0	28.0
	SAES	5.3	8.0	11.0	16.0
	Total	14.6	22.0	31.0	44.0

Facility Needs to Support the Recommended Research Effort, RPA 405

To accomplish the above goals, there is a need for the development of a major Federal facility and State facilities to accommodate the projected increase of research personnel. The major Federal facility for housing the expanded program (18.7 SMY's) would cost approximately \$600,000.

State facilities would cost approximately \$300,000. These would accommodate 10.7 SMY's projected by the recommendations.

Those facilities would be used for having the expanded programs projected herein for the production of field crops with improved consumer acceptability.

Research Problem Area 406 - New and Improved Food Products
from Field Crops

Situation

Although it is a byproduct of the cotton industry, cottonseed is an important agricultural commodity. Income from cottonseed to U. S. cotton growers over the past 10 years averaged \$275 million a year from an average annual production of 5.7 million tons, and reached over \$300 million for a production of 6.5 million tons in 1964. Only four crops, including cotton lint, ranked higher in value than cottonseed in the 14 major cotton growing states in 1959 and 1960. The 11 percent of total income that it contributes to cotton-growing income is larger than the average net profit from growing cotton, and is thus essential to the successful price competition of lint cotton with other fibers. Production was sharply reduced in 1966, owing to adverse climatic factors combined with sizable reduction in cotton acreage; however, production is projected to increase by at least 20 percent of the past 10-year average by 1980.

Traditionally cottonseed oil, valued at over \$200 million annually, has moved into food uses, while the meal, valued at about \$180 million has found its major application in animal feeding uses. Unfortunately, the competitive position of cottonseed oil has been seriously challenged over the last two decades. For many years, cottonseed ranked first in importance as a source of vegetable fats and oils, in terms of both the quantity consumed annually, and the quality of its products. This preeminent position of cottonseed oil has gradually declined because of the improved quality of competitive products and their availability at substantially lower prices.

Growing world needs for high quality sources of protein, on the other hand, not only opens up new usage areas to cottonseed food products, but imposes the obligation to develop sources of high quality protein from this important oilseed.

Research to develop new and improved cottonseed food products thus offers attractive opportunity not only to stabilize markets for the present production of cottonseed and its products, but to provide new outlets for the projected 20 percent increase in production.

Specific Research Units, RPA 406

A. Better cottonseed food products.

1. Situation: Cottonseed oil historically accounts for about 55 percent and meal about 33 percent of the total value of products produced from cottonseed. In the past, cottonseed oil has occupied a premium product position relative to other fats with which it competes. However, a substantial degree of interchangeability of fats and oils for various end-uses through improvements in processing technology of competing oils resulting from research now threatens cottonseed oil's preeminent position. While per capita consumption of fats and oils has remained at about 45 pounds (of which an increasing amount is margarine, shortening, and salad and cooking oils produced from vegetable oils) from 1940 to 1964, cottonseed oil's share of the market decreased from 45 percent to 7 percent of margarine, and from 69 percent to less than 14 percent of shortening. This decline in the dominant position of cottonseed oil has been caused by price and bleach color disadvantage and by technological advances of competing products.

Cottonseed meal traditionally has gone into animal feeding uses, with only very minor application in foods. For the latter, the presence of components such as gossypol and crude fiber acids in cottonseed has been a deterrent.

Additional research effort is needed in all areas of the processing by which crude cottonseed oil is converted into its existing end-use products. There is also urgent need for research directed toward entirely new edible products, based on cottonseed oil, as well as improvements and innovations in existing products. Attention also should be directed to producing flours of satisfactory flavor and color characteristics through adjustments in processing, to remove deleterious components, to prevent heat damage to the protein, to increase the protein content of the flours through removal of nonprotein components such as fiber, and perhaps a part of the raffinose, and to the development of protein isolates and concentrates from cottonseed suitable for food uses. Success in these endeavors offers the best promise for retaining present markets for cottonseed oil in the face of competing materials, and for developing higher value outlets for cottonseed meal. In addition, edible cottonseed flour will provide for use both domestically and abroad a nutritious human food at low cost. Such increased food uses have great potential for providing outlets for projected increases in cottonseed production.

2. Objective: To develop improved processes for and products from cottonseed oil and meal for food uses.

3. Research approaches:

- a. Improvement in oil quality.
- b. Improved food products.
- c. Improved processes to lower cost.
- d. Cottonseed flour for food uses.
- e. Protein isolates and concentrates.

4. Character of potential benefits: Improved processes and products from cottonseed oil and meal for food.

Recommended Research Effort, RPA 406

It is recommended that the total scientist man-year research effort (USDA, SAES, and industry) be 30, 35, and 40 for Fiscal Years 1969, 1972, and 1977, respectively. In view of this total requirement, the recommended USDA and SAES research effort is shown below:

TABLE 15.--Scientist man-year research requirements, RPA 406

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Better cottonseed food products	USDA	25.7	22.0	26.0	30.0
	SAES	0.2	2.0	3.0	4.0
RPA 406 Total		25.9	24.0	29.0	34.0

Facility Needs to Support the Recommended Research Effort, RPA 406

Facilities under construction at New Orleans will provide for the projected 4 SMY additional Federal effort. The facility requirements for the projected State Agricultural Experiment Station Program cannot be precisely determined but current facilities are generally inadequate. On the basis of the projection for four additional scientists and an estimated \$25,000 for facilities to support each scientist (allowing 500 square feet per SMY and an estimated cost of \$50 per square foot in construction costs), the total SAES needs for this RPA will aggregate about \$100,000 by FY 1977.

Research Problem Area 407 - New and Improved Feed, Textile, and Industrial Products from Field Crops

Situation

Textile Processing Efficiency

The major opportunities for cotton in mill processing research lie in 1) improving the uniformity of yarns and fabrics; 2) utilizing cotton's full fiber potential in processing and products; 3) more efficient removal of waste from spinnable stock, including better separation of short fibers from the spinnable lengths; and 4) streamlining cotton production methods as much as possible to increase efficiency.

Cotton's century and a half of use as the principal textile fiber has led to a high degree of efficiency in both processing methods and equipment. In fact, the "cotton system" has become the basis for almost all textile manufacturing operations. It is perhaps understandable that it is not a simple matter to devise entirely new processing methods and equipment for cotton. Most of the innovations during the past quarter century have been adaptations or modifications of existing systems and equipment.

The use of synthetic fibers brought about the first major departures from conventional textile processing methods. With waste-free synthetics, most of the cleaning equipment used in the cotton system could be bypassed. Synthetics have less need for elaborate blending procedures, since quality is generally more uniform and more rigidly specified. Synthetic staples come in any length and in a wide range of fiber diameters, thus facilitating certain processing operations, and offering new possibilities for adapting various types of fibers to specific applications. The development of machines that make possible the tow-to-top processes make it feasible to bypass entirely the traditional opening, picking, and carding stages. Continuous filament yarns, of course, eliminate even the need for spinning.

Cotton cannot match the wide range of sizes and staples available in synthetics. Neither can it be used in certain of the short-cut processes which can be adapted to the manufacturing of synthetic fiber products. But cotton's disadvantage is not as great as it might seem. Cotton's surface characteristics, extensibility, strength, and lack of susceptibility to electrostatic charges also adapt it well to textile usage. But even marginal improvements in the processing efficiency and in the quality of cotton products can be important, especially in uses where there is strong interfiber competition.

In general, the prospects for reducing the costs of cotton products are not as promising, in the absolute sense, at the mill processing stage as in the production of the fiber itself. The opportunities that are significant at the processing level are mainly those which overcome cotton's disadvantages relative to synthetics, or which may give cotton some special advantage. Thus, research directed toward more efficient and more effective removal of waste from cotton would improve cotton's position relative to the waste-free synthetic staples. On the other hand, research on weaving could be expected to benefit synthetics almost as much as cotton, and from the cotton viewpoint that type of research would command a relatively low priority. The important areas of mill processing research on cotton would therefore be, in addition to better waste control, studies directed toward overcoming the nonuniformity of staple lengths in cotton and their effects on processing performance and yarn quality, and to compensating for the variabilities in other properties which are inherent in an agricultural raw material.

The overall objectives of cotton mill processing research are to reduce cost and to improve quality. While these seem clear-cut, it is generally not so easy to assign a particular line of study to one or the other, because most mill processing research affects both quality and cost. Of the six areas of cotton mill processing research suggested, therefore, two can be said to be directed mainly toward quality improvement, and one mainly toward cost reduction. The other areas affect both cost and quality.

Technological developments in the production, harvesting, and ginning of cotton may necessitate changes in the direction and emphasis of mill processing research from time to time. As the textile raw material changes, or reaches the mill in some new condition, processing conditions may require modification for optimum adaptation to cotton's new form.

Improved Product Properties (cotton)

The performance, or use qualities of textile products vary widely, as might be expected, since textile products go into literally hundreds of different uses. Each use category has its own set of performance properties, or consumer values. In certain industrial uses these quality criteria have been formalized in actual performance specifications. More frequently, however, these criteria simply represent the qualities which consumers desire and consequently seek in their purchases of various textile products. For example, in rainwear, they want, first of all, either water resistance or water repellency. They would also like to have, if possible, the comfort which is associated with water vapor permeability. However, protection from rain is sufficiently important so that many consumers will forego comfort for protection and will use impermeable plastic raincoats.

Consumer preference surveys--on rainwear--show that a number of additional characteristics also have various degrees of significance. Color fastness, dimensional stability, quick drying, soil resistance, luster, and smooth drying properties all influence consumer purchases. Lightweight, drape, wear life, lack of odor, and mildew and stain resistance are lesser considerations. Certain factors, such as hand, pilling resistance, and wind resistance play a minor role in consumer preferences for rainwear fabrics.

Consumers look for quite different qualities in handkerchiefs, and still another combination in dresses, or hosiery, etc. Price and promotion apart, they select the rainwear, the handkerchiefs, the dresses, or the hosiery which best meet their quality requirements.

The maximum use of cotton can best be assured by improving those quality characteristics which consumers demand in each significant textile product category. If consumers want rainwear which sheds rain, cotton cannot be sold without water-repellent or water-resistant qualities--not so long as satisfactory competitive products are available. But if cotton rainwear provides both protection and comfort, it will have an advantage over rainwear giving protection only. And if cotton rainwear provides protection, comfort, and the other qualities which consumers consider significant in rainwear--and if cotton rainwear at the same time has important advantages of economy--only a great disparity in promotion in favor of competing materials would prevent cotton from dominating the rainwear market.

The starting point to improving the competitive strength of cotton, therefore, is a knowledge of the qualities which consumers seek in textile products. Market research is the tool which has been utilized to provide this information.

More than 400 textile end-use items have been surveyed in studies conducted by the National Cotton Council. Various market research techniques have been employed--consumer preference surveys, retail store visits, inquiries into various channels of trade, and others. More than 50 different qualities have been specifically identified by consumers or trade sources in these 400-odd textile end-uses.

Many of the consumer quality terms mean different aspects of the same thing; for example, smooth drying, resistance to wrinkling, resiliency, and durable creases. In addition, many different qualities are influenced by the same physical or chemical characteristics of the fiber--the fiber property resilience in this case. Consolidating the 50-odd quality terms which consumers use, and then subjecting this compendium to a technical analysis yields just five different areas of research investigation: 1) resilience properties; 2) chemical properties; 3) shape and surface properties; 4) tensile strength properties; and 5) miscellaneous properties.

Within any one of the research areas different types or degrees of changes may be required to upgrade quality; for example, both mildew resistance and fire resistance are chemical properties. Both properties may be obtained either by additive finishes or by chemical modifications of cotton. However, the treatment or modifications which impart one quality may or may not also impart the other. It is apparent, therefore, that while research on the chemical reactivity of cotton, and on its response to various finishing treatments, is basic to either property, specialized chemical treatments may be required to optimize one or the other.

Product Development (cotton)

The first step in cotton product development usually calls for research on the improvement of one or more specific consumer qualities. In some cases, this may be all that is necessary to make a cotton product more competitive: simply an added, or higher performance rating, in a particular functional property. However, in most cases a change in one quality or property results in changes in others, frequently of an adverse nature. Therefore, product development research, to be effective, generally requires attention to all of the significant functional properties of the product, and the use of both chemical and physical modifications to optimize the balance of these properties.

Cotton product development research, in summary, involves the following four steps, the first two of which are mainly concerned with improvement of consumer qualities, and the last two with the whole product:

- a. Broadly based research on mechanisms and methods in each of the five research areas in which cotton property modifications could lead to the upgrading of a group of consumer qualities.
- b. Further development of specific chemical, physical, and structural modifications calculated to achieve the desired improvement in individual consumer qualities.
- c. Refinement of specific research-based improvements to minimize any reductions in other useful properties of the cotton product or to enhance the value of certain secondary properties.
- d. Research to reduce the cost or improve performance levels of the specific new or improved process or product.

The basis on which priorities can be set for the development of more competitive cotton products deserves explanation.

The starting point in product development--quality improvement--permits certain logical priorities to be assigned. These are based on the volume of consumption of cotton and competing materials in which improvement in certain key qualities would strengthen cotton's competitive position. Initial priority ratings were established by this method simply by following an appropriate ranking of these properties. The technical feasibility of achieving certain improvements, however, required some modification of this priority assignment. For example, it has proved impossible thus far to increase the luster of cotton to levels found in certain synthetic fibers. This consideration, together with the dependence of several important consumer properties on resilience, has therefore given resilience improvement the top priority.

The matter of urgency also figures in the assignment of priorities for cotton research. For example, improvements in cotton sheets would normally command a very low priority. Few products fit the requirements of consumers better than a cotton sheet. Cotton provides comfort, economy, good wear life, launderability, and a variety of color and styling effects in sheets. Opinion studies show that most consumers are well satisfied with all-cotton sheets. Nevertheless, polyester-cotton blend sheets are being heavily promoted by synthetic fiber manufacturers and cooperating mills simply because the sheet market represents a huge potential outlet for any fiber and thus is immensely attractive to the polyester producers, and polyester cotton sheets represent a novelty for cooperating mills in which most of the promotional support comes from the fiber producer. So far as the consumer is concerned, the blend sheets will be promoted on the basis of no need for ironing and having some vaguely defined durability characteristics.

This type of blend promotion in one of cotton's key markets obviously gives research on smooth-drying cotton sheets a much higher priority than it would normally command. Competitive pressure, therefore, must be a major consideration in the establishment of the priorities for cotton product research.

The magnitude of the effort required to develop, improve, and commercialize more competitive cotton products should not be underestimated. This type of research is expensive. It takes time. And it never ends. So long as the synthetic fiber manufacturers continue their huge expenditures for research and development, cotton's position in any and all of its markets will be constantly imperiled. Only a continuing effort to upgrade each product line, to match any characteristics offered by competitors, and to provide adequate promotional support for cotton products will enable these markets to be held.

Factors involved in seed crushing, the processes by which cottonseed is separated into its primary products, oil, meal, linters, and hulls, affect the yield and quality and, hence, the value of these products, which in 1964 aggregated about \$420 million at the processor's level. The present state of seed crushing technology owes much to past research and development activities in this area. There is, however, need for additional research to improve processing efficiency and to afford higher quality oil and meal products of greater utility.

Cottonseed oil, traditionally, has been used primarily for food products. The relatively small quantity that has been used for industrial purposes has comprised fatty acids derived from soapstock, a byproduct of crude oil refining. Owing to the rather large proportion of palmitic acid and the relative absence of acids more unsaturated than linoleic, cottonseed oil has attractive industrial use potential. Research to develop new fatty acid derivatives could provide outlets for the same 25 percent of cottonseed oil that is too dark for satisfactory preparation of shortenings and margarine.

Cottonseed meal traditionally has been consumed primarily as an animal feed, and has enjoyed little application as an industrial raw material. Its suitability in animal rations is dependent upon factors affected by processing, such as the presence of gossypol and cyclopropene acids, the amount of residual oil in the meal, and the extent of heat damage to the protein. Research is needed to optimize these processing factors or to devise new processes to yield cottonseed meal of highest quality to permit its unrestricted feeding to all animal species.

The industrial use potential of cottonseed proteins is a largely unexplored field, despite the fact that they possess molecular dimensions that are desirable for uses such as sizings and the like. Attention should be directed to obtaining basic information concerning the conformation of the proteins in cottonseed and to the development of protein isolates and concentrates having physicochemical characteristics tailored to specific industrial applications.

Specific Research Units, RPA 407

A. Textile production efficiency.

1. Situation: Cotton is facing increasing competition with man-made fibers. Research to reduce cost while maintaining or improving quality characteristics is essential to meeting this competition. The major opportunities for reducing cost in mill processing lie in 1) improving existing processes; 2) developing radically new processing systems; 3) improving product uniformity; and 4) better control of waste.

As might be expected with a natural raw material, cotton shows greater variability of properties than the man-made fibers. Cotton of different varieties and cottons grown under different environmental conditions will frequently vary widely one from another in average fiber characteristics, while the fibers in each type will differ from the average of that type. In addition, cotton as received at the mill contains foreign materials which must be removed.

Yet, in spite of the wide variability in the properties of cotton within any quantity such as a bale, and between bale lots, textile processing has been reasonably successful in averaging out many of the variations in cotton's properties. This is accomplished by employing a large number of processes through which the fiber must pass before the final product is completed.

However, both long- and short-term variability are major problems in producing cotton textiles of high consumer acceptance. Some of the nonuniformity in cotton textiles stems from the variable properties of the individual fibers and some from the processing equipment itself, such as the drafting rolls which are known to produce a "drafting wave." Therefore, research is needed on sources of nonuniformity and ways to reduce unevenness through improvements in equipment and processing techniques.

The biggest margins for cost cutting lie in spinning and weaving, in each of which cost ranges between 10 and 15 cents a pound for labor and overhead. However, improvements in these operations may be applied in large part to synthetic fibers, unless radically new systems specific for cotton processing are developed. Hence, on a short-term applied basis, cotton's most clear-cut advantages in cost reduction research can be found in the early manufacturing processes--opening, picking, and carding. Labor and overhead charges for opening and picking range from 1/2 to 1 cent per pound, and for carding from 1 1/4 cents to 2 1/2 cents. In print cloth manufacturing these costs average about 0.6 cents per pound and about 1.5 cents per pound, respectively.

Entirely new and unique processing systems are also needed. The cotton textile industry is striving to produce low-cost, quality products using equipment conceived two hundred years ago and based on a system of discontinuous multistage processing. The modern cotton mill utilizes 10 to 15 individual processes and, compared with competitive manufacturing systems, an excessive amount of labor. Further, the harsh treatment of the cotton by conventional textile equipment is well known. The resulting fiber breakage increases processing costs and lowers the quality of the products.

For example, cotton costing the mill 24.50 cents per pound under the present one-price system sells in the form of 30/1 carded yarn for 70 cents per pound. A 50 percent decrease in mill processing costs achieved through the development of a new, continuous processing system would lower the cost of this yarn an estimated 16 cents per pound, a truly significant contribution to increasing cotton utilization. A similar decrease in the processing cost of all cotton yarns would result in almost \$1 billion potential reduction in consumer costs. A continuous processing system would also result in increased uniformity, strength, appearance, and other properties of cotton products. In addition to lowering consumer costs and increasing utilization, it is anticipated that added profits and increased exports will result.

Research is needed to control waste during textile processing. Each bale of raw cotton shipped to mills contains from 10 to 40 pounds of nonfibrous waste, and in some cases equivalent amounts of fibers so short that they contribute no useful quality to yarns and fabrics. Unless removed during processing, both nonfibrous waste and short fibers reduce quality and, consequently, the value of cotton yarns and fabrics. Generally, efforts to remove waste and short fibers during processing result in loss of appreciable amounts of longer, spinnable fibers, while some trash still remains in the stock.

The average loss in waste in carded yarn products, which comprise about 70 percent of total cotton manufactures, is about 15 percent. This effectively adds about one-sixth to the net cost of cotton to mills, less the amount returned by sale of the waste. Even the amount recovered from the waste might be substantially increased if that waste could be efficiently separated into fibrous and nonfibrous components. Clean, fibrous waste would find many ready markets, including nonwoven fabrics, papermaking, fillers for plastic laminates, and as high-grade filling and stuffing material.

2. Objective: Overall objective is to improve efficiency of mill operation and product quality.

3. Research approaches:

- a. Improve existing equipment.
- b. Optimum textile organizations.
- c. Increased production rates.
- d. Increased machine efficiency.

e. Continuous spinning systems.

1. Electrostatic.
2. Aerodynamic.
3. Sonic and ultrasonic.
4. Hydrodynamic.

f. Continuous fabric production systems.

1. Electromechanical.
2. Adhesive bonding of yarns.
3. Three-dimensional fabrics.

g. Fiber property effects on quality.

h. Interaction of fiber properties and processing variables.

i. Temperature-humidity-time effects.

j. Raw cotton cleaning.

k. Short fiber removal.

4. Character of potential benefits: Reduction in manufacturing costs and greater uniformity of product.

B. Higher manufacturing quality.

1. Situation: While the physical properties of cotton do not differ from one variety or type to another as widely as variations which make one special synthetic staple different from another, differences in cottons may nevertheless profoundly influence mill processing performance. Certain products can be made from one type of cotton but not from another. Even the end-use performance of cotton products can be influenced to a significant degree by the type of cotton from which they are made.

A considerable body of research information has been developed on the mill processing adaptations which can be made to accommodate certain differences in fiber properties. For example, optimum twist factors for various degrees of fineness in cotton and for different staple lengths have been determined. Drafting ratios for various yarn counts, produced from different types of cotton, have been studied. The contribution which specific cotton fiber characteristics, such as strength and length, make to the performance properties of yarns and fabrics has been investigated.

Even in the areas which these studies have covered, however, the information is far from complete. In addition, research has yet to provide clear guides on the adaptation of particular types of cotton for optimum product performance in specific end-uses. Furthermore, apart from length, strength, and fineness, other physical properties in cotton which may be important in processing and in end-product performance have not been thoroughly investigated. Many varieties and types of cotton, important to growers in large areas of the Cotton Belt, need more thorough studies to determine which products and processes offer them the most promising outlets. The urgency of this problem is emphasized by the recent shift of publicly held cotton from high to low quality. The cotton 31/32 inch and shorter in staple has increased to 52 percent of the CCC stocks from 37 percent in the six months preceding January 1967. In contrast, only 8.6 percent of CCC stocks in January 1967 was 1 1/16 inch and longer. Similarly, CCC stocks of below 3.5 micronaire and above 4.9 micronaire cotton increased a half-million bales in 1965, and about 2 million bales in 1966.

As new methods, machines, and auxiliary equipment are developed for the manufacture of cotton products, deliberate selection of fiber types for optimum performance in these new systems will be desirable. Probably some adaptations of these new systems to different cotton types will be necessary in some cases. Thus, the mill processing research described here contemplates an extension of studies which have already been shown to be useful, and the initiation of additional lines of work designed to accommodate a changing environment in mill processing techniques.

2. Objective: Methods and processes to utilize effectively all grades and types of cottons regardless of fineness, coarseness, or staple length.

3. Research approaches:

- a. Low micronaire cotton.
- b. High micronaire cotton.
- c. Short staple cotton.
- d. Standard grades.

4. Character of potential benefits: Provide uses for low-grade cottons in quality cotton products.

C. Improved finishing efficiency.

1. Situation: Just as in the mill processing of cotton, the operations of finishing cotton yarns and fabrics offer certain opportunities for reduced costs through greater efficiency and for improved quality. In general, however, the potentials for cotton in modifications of the more or less conventional processes of scouring, bleaching, mercerizing, and dyeing are not highly significant to its competition with synthetic fibers. On the other hand, there is still considerable room for improvement in the methods of applying some of the newer resin and chemically reactive finishes used for wash-wear and durable press properties.

Research directed toward improving the finishing technology applicable to cotton fabrics should be directed toward 1) development of the optimum combination of processing conditions and equipment types for achieving the maximum response from resin and chemical crosslinking treatments with the minimum loss of the inherent properties of cotton and 2) exploration and development of new and novel processing methods and equipment which will broaden the applicability of new finishes to cotton, reduce the deleterious effects of conventionally applied finishes, or alleviate problems concomitant with conventional wet finishing (stream pollution, for example).

2. Objective: Development of optimum combination of processing conditions and equipment types for achieving maximum response from wet treatments with minimum loss of inherent cotton properties, and exploration and development of new and novel processing methods and equipment.

3. Research approaches:

a. Wet operations.

1. Effect of additives at the gin on processing.
2. Sizing.
3. Desizing and scouring.
4. Solvent finishing.

b. New methods.

4. Character of potential benefits: Opportunities for reduced costs through greater efficiency and for improved product performance.

D. Durable press, warmth, and other resilience properties.

1. Situation: Increased resilience could improve a number of cotton consumer qualities, including wrinkle resistance, warmth properties, abrasion resistance, and drape. If the same improvement in resilience could be achieved while maintaining or even increasing cotton's normal extensibility, wrinkle resistance, abrasion resistance, and drape might all be improved. Such properties as warmth, and crush resistance in carpets might, at least in some constructions, require still other types of resilience.

Perhaps the greatest contribution that cotton with improved resiliency can make is in the durable-press market. Cotton is losing a major share of its important apparel markets due to the new durable-press finish now sweeping the garment industry. The advent of durable-press finishing has led to the application of high levels of crosslinking agents, resulting in a substantial decrease in the wear and abrasion resistance of all-cotton products of this type. The textile industry is resorting to blends of synthetics with cotton (usually containing 50 percent or more of polyester) to minimize the abrasion problem. Durable-press products, based largely on synthetics and their blends, are rapidly expanding in apparel and household markets. Improvements in durable-press qualities of cotton are important, therefore, in order to:

- a. Enable cotton to compete in the 3.3 billion-square-yard easy-care market currently held by synthetics.
- b. Enable cotton to maintain its position in the 2.0 billion-square-yard market currently held by easy-care cottons.
- c. Prevent synthetics from taking the 2.9 billion-square-yard market which represents expansion potential for all easy-care fabrics and which is currently held almost entirely by regular finish cottons.
- d. Prevent synthetics from further encroaching on markets traditionally dominated by cotton such as bed sheets and pillowcases currently using over 1.2 billion square yards.
- e. Develop better and more useful products to meet consumer wants and needs.

The above totals 9.4 billion square yards which is equivalent to approximately 7.7 million bales of cotton valued at \$1,155 million at the farm level, \$8.5 billion at the retail level, and would cost the government about \$300 million in carrying charges until sold.

Benefits in terms of increased exports fall into two categories. Improved products would permit domestic textile manufacturers to increase their sales of cotton textile products abroad, which totaled more than \$250 million in 1964. It would also materially aid exports of raw cotton by providing technology for the production of satisfactory all-cotton apparel, thus limiting the increased use of synthetics by foreign textile manufacturers. Export markets for cotton have been projected at from 5.3 to a possible 12.4 billion bales for 1980, depending on several factors, including availability of adequate processing technology.

Substantial benefits to the consumer would also result from the availability of more durable, comfortable, and easily cleaned apparel. Combined savings attributable to home laundering of shirts and sheets alone have been estimated as high as \$85 annually per family unit.

2. Objective: Development of finishes and processes to improve resiliency of cotton products important in apparel and household markets.

3. Research approaches:

a. Wrinkle resistance and no ironing.

1. Fiber structure.
2. Breeding.
3. Deformation and recovery in cotton.
4. Resin deposition and side-chain formation.
5. Quantitative determination and distribution of crosslinks.
6. Wet and dry recovery.
7. Tensile strength and abrasion losses.
8. External agents.
9. Creaseproofing agents.
10. Catalysts.
11. Processing.
12. Yarn and fabric construction.
13. Testing.
14. Shape-holding cotton garments with durable creases.

- b. Resistance to puckering and tailorability.
 - 1. Effects of fabric mechanical parameters on puckering and tailorability.
 - 2. Contradiction between wrinkle resistance and tailorability.
 - 3. Improvements in garment-making techniques.
- c. Resistance to matting and resiliency.
 - 1. Improved elastic recovery of individual fibers.
 - 2. Improved fiber surface properties.
 - 3. Improved construction.
 - 4. Improved fiber-to-fiber bonds.
- d. Elasticity and elongation.
 - 1. The "Setting" methods.
 - 2. Slack mercerization and crosslinking.
- e. Dimensional stability.
 - 1. Causes of dimensional changes in laundering.
 - 2. Mechanical preshrinking.
 - 3. Chemical stabilization.
- f. Warmth, thermal insulation, and resistance to wind penetration.
 - 1. Lofting and setting.
 - 2. Fiber treatments.
 - 3. Construction characteristics.
- g. Drape, hand, and permanent crispness.
 - 1. Fiber properties and fabric construction characteristics.
- h. Soft colors.
 - 1. Fabrics with three-dimensional surfaces.

4. Character of potential benefits: Improved resilience properties in cotton products to compete with synthetic fibers and materials.

E. Fire-, weather-, water-resistance and other chemical properties.

1. Situation: It has been estimated that outdoor weathering is important in textile outlets consuming more than 353,281,000 pounds of all fibers annually, the equivalent of approximately 700,000 bales. Of this market, 154,650,000 pounds, or more than 300,000 bales of the fibers, are cotton.

In some specific end-uses (tentage, awnings, tarpaulins, etc.) cotton is and has long been the principal textile fiber used; however, each year there is a decrease in the percentage of the total market held by cotton. Constant inroads into this total are being made by synthetic fiber materials, as well as by unsupported plastic film and sheeting. High among the competitive factors in end-uses for this market are weight and resistance to fire, water, sunlight, and microbiological attack. A lightweight treatment for cotton fabrics affording the aforementioned resistance characteristics and retaining cotton fabric's unique "breatheability" and seam and sewing characteristics would substantially improve the competitive position of cotton.

Another important chemical property is flame resistance. The annual potential for fire-resistant finishes on woven cotton fabrics is equivalent to 354 million pounds of fabric. Since only 19 million pounds of cotton fabrics were finished for fire resistance in 1963, the unfilled potential is equivalent to 335 million pounds of cotton fabrics annually. Additional markets for flame-retardant cottons are possible, equivalent to 423 million pounds of treated cotton fabrics through gains against competing fabrics. According to Public Health Service estimates, 150,000 persons in this country are burned each year in accidents in which clothing is set on fire; thousands more are burned from bedding and home furnishing fires. Published reports indicate that accidents by fire and explosion are the second leading cause of nontransport accidental deaths in the United States. Because of these numerous casualties, legislative measures have been initiated to require flame-resistant fabrics for many uses. Immediate expanded research is necessary to insure the retention of cotton in these markets. In the case of automobiles, recent congressional actions with regard to safety demand the development of flame-retardant cushions from cotton to retain markets for more than 500,000 bales of cotton and byproducts from cotton processing. Some State legislatures are considering flame retardancy laws for bedding and furniture. These markets amount to 700,000 bales of cotton and byproducts from mill operations.

Inexpensive, nondurable finishes which impart excellent flame resistance to cotton are readily available. Typical of such finishes are the borax-boric acid compositions, used on fabrics where laundering or water leaching will not be encountered. Durable finishes have also been developed. Most of these, however, are still relatively expensive, even for those uses which reflect the greatest demand for fire-resistant properties. Cotton could benefit from research directed toward inexpensive, durable flame retardants that have little adverse effect on fabric properties.

Other chemical properties of importance include elasticity and elongation; dimensional stability; warmth, thermal insulation and resistance to wind penetration; drape, hand, and permanent crispness; and soft colors.

2. Objective: Development of finishes that would impart a high degree of chemical resistance to cotton products.

3. Research approaches:

- a. Resistance to weathering.
 - 1. Mechanisms of degradation.
 - 2. Protective treatments--additive.
 - 3. Protective treatments--reactive.
 - 4. Test methods.
- b. Resistance to fire.
 - 1. Mechanisms of combustion.
 - 2. Protective treatments--additive.
 - 3. Protective treatments--reactive.
- c. Resistance to chemicals.
 - 1. Protective treatments--additive.
 - 2. Protective treatments--reactive.
- d. Resistance to heat.
 - 1. Mechanisms of degradation.
 - 2. Protective treatments--additive.
 - 3. Protective treatments--reactive.

e. Electrical insulation and quick drying.

1. Protective treatments--additive.

2. Protective treatments--reactive.

4. Character of potential benefits: Enable cotton to compete in markets where chemical properties are important, especially for outdoor uses and in uses where flame resistance is essential. Contribute materially to reducing death and injury from fires.

F. Luster, smoothness, and other surface properties.

1. Situation: Luster, soil and stain resistance, water repellency, smoothness, and resistance to clinging are consumer qualities which depend largely upon the shape and surface properties of yarns and fabrics. These shape and surface properties, in turn, result from the combined effects of the fiber's physical and chemical surface, the manner in which fibers are arranged in yarns, and the arrangement of the yarns in fabrics. Modification of the shape and surface characteristics of cotton fibers, yarns, and fabrics can contribute to improvements in the consumer qualities listed above. The relative importance of these quality improvements for cotton have been measured in volume of other materials consumed in uses in which these specific quality improvements would strengthen cotton's position:

<u>Quality</u>	<u>Consumption of other materials (million pounds)</u>
Luster	1,787
Resistance to soiling	1,380
Resistance to staining	905
Water repellency	566
Resistance to wrinkling	1,003
Resistance to clinging	61

2. Objective: Develop cotton products with high luster, soil, and stain resistance, water repellency, smoothness, and resistance to clinging.

3. Research approaches:

a. Luster.

1. Contribution of fiber surface and internal structure to luster.
2. Yarn and fabric construction.
3. Finishes.

b. Soil and stain resistance.

1. Mechanism of soil retention.
2. Yarn and fabric construction.
3. Finishes.
4. Development of soil hiding power.
5. Test methods.

c. Water repellency.

1. Durable hydrophobic surfaces.
2. Water-resistant, water-vapor permeable fabrics.

d. Smoothness and resistance to clinging.

1. Fiber properties.
2. Yarn and fabric construction.
3. Finishes.
4. Test methods.

4. Character of potential benefits: Increased markets for all-cotton products.

G. Strength, low bulk, sheerness, and related properties.

1. Situation: A recent compilation of annual growth rates of various products indicates that production of all man-made fibers has been growing at an average annual rate of 5.5 percent between 1948 and 1963. Assuming an inevitable slowdown in rate of growth as products near maturity, man-made fibers should still nearly double in the next 10 years. On the other hand, cotton consumption has fallen off regularly at about one percent per year. Estimated on equivalent weight basis, domestic fiber consumption of cotton is now less than 50 percent of textile fibers used when compared to man-made fibers. A contributing factor is the improvement in fiber properties attained by man-made fiber producers. For example, the tremendous advance in cellulose chemistry has produced a new generation of rayon fibers of improved wet strength and toughness. It has been estimated that in 1963 the man-made fiber producers invested \$108 million in research and development; one company alone stated that 1965 expenditures will exceed \$50 million. A competitive utilization research program on cotton, therefore, is essential to provide products of suitable strength and toughness to meet the growing demand for these improved textile properties. It has been estimated in a study made in 1959 that the relative importance of strength improvements for cotton are equivalent to markets that total over 2.6 million bales, of which cotton held less than 1.2 million bales. If only half of this potential is achieved by successful research to produce cotton products of increased strength and toughness, increased new markets of a million bales of cotton, valued at \$150 million at the farm level, can be expected. In addition, substantially greater benefits would be expected to result from the retention of expanding markets presently held by cotton because of the improved competitive position of stronger, tougher cotton.

Tensile strength directly or indirectly influences a considerable number of consumer qualities of textiles and is perhaps the most important single factor determining the selection of textile fibers for industrial uses. Strength is important in itself since textile structures must meet minimum strength specifications in various end uses. However, tensile strength is also closely related to cost and has a direct effect on such functional qualities as bulk, weight, and tear strength. In apparel, sheerness qualities require the use of high strength, fine yarns. Indirectly, strength affects the wash-wear market, since the wash-wear performance of cotton fabrics could be further improved if tensile strength were not adversely affected by the more rigorous chemical finishing processes required.

Research on cotton tensile strength has included studies on 1) fiber properties in relation to internal structure, 2) yarn and fabric construction, 3) transmission of fiber strength to yarn and fabric strength, and 4) effects of finishing agents. Yarn strength can be increased by control of such construction parameters as fiber length, fineness, and twist, by stretching while wet, and by chemical treatments which increase interfiber friction. However, yarn strength is governed to a large extent by fiber strength. Significant improvement in the strength of cotton yarns and fabrics is highly dependent upon substantial increases in fiber strength and strength-length uniformity. Methods of improving the translation of fiber strengths into yarn and fabric strengths are badly needed also. One such method might involve the development of yarn structures which maintain adequate fiber cohesion with little or no twist. Finally, a breakthrough in chemical finishing technology to prevent strength loss during wash-wear treatments is an important need.

2. Objective: Methods to substantially increase fiber strength and strength-length uniformity, and to improve translation of fiber strength into yarn and fabric strength.

3. Research approaches:

- a. Fiber strength.
 1. Molecular orientation.
 2. Identification and elimination of weak spots.
 3. Isolation of weak spots.
 4. Strength of crosslinked cotton.
- b. Translation of fiber strength to yarn strength.
 1. Fiber inclination to yarn axis.
 2. Fiber slippage.
 3. Effective grip length of fibers in yarns.
 4. Fiber ends at point of yarn rupture.
 5. Variation in fiber elongation.
- c. Transmission of singles yarn strength into other textile constructions.
 1. Plied constructions.
 2. Fabrics.
- d. High strength nonwoven structures.

4. Character of potential benefits: Increased markets for all-cotton products.

H. Abrasion and linting resistance and related properties.

1. Situation: Of the 53 consumer qualities described in marketing studies, most can be classified into the four areas: resilience properties, chemical properties, shape and surface properties, and tensile strength properties. There are several other consumer qualities, however, which for various reasons cannot be so easily categorized: coolness, permeability, washability-cleanability, and resistance to abrasion, linting, snagging, and pilling. For convenience, these properties have been brought together under the category of abrasion and linting resistance and related properties.

Markets for cotton and competing materials are divided into three main groups--industrial, household, and apparel. Major changes in the pattern of cotton consumption relative to competing materials in these broad uses since World War II are as follows:

	Consumption of cotton	
	<u>1947</u> (Percent)	<u>1964</u> (Percent)
Industrial uses	44	24
Household uses	56	49
Apparel uses	56	61

Total consumption of all materials in 1964 was equivalent to 6.0 million bales in industrial uses; 5.5 million bales in household uses; and 7.6 million bales in apparel uses. The total market for industrial uses has not changed significantly; however, substantial increased consumption has occurred in household and apparel uses, totaling the present 14 million bale equivalents. In general, apparel and household uses represent the greatest growth market potential for cotton. More than any other fiber, cotton can be given the wide range of physical or chemical properties and necessary balance of esthetic qualities needed for all types of apparel and household uses. Immediate potential for cotton in these two broad outlets is equivalent to 8.8 million bales annually. Although only a portion of this market could be captured, a small percentage increase in cotton usage would be reflected in large volume gains.

2. Objective: Develop cotton products with new and improved properties for industrial, household, and apparel uses.

3. Research approaches:

- a. Resistance to abrasion.
 - 1. Mechanism of abrasion.
 - 2. Fiber mechanical properties.
 - 3. Yarn and fabric construction.
 - 4. Fiber modification.
 - 5. Additive finishes.
 - 6. Testing methods.
- b. Coolness and permeability.
- c. Washability-cleanability.
 - 1. Fiber modification.
 - 2. Additive finishes.
- d. Resistance to linting.
- e. Resistance to snagging.
- f. Resistance to pilling.

4. Character of potential benefits: Increased markets for all-cotton products.

I. Improved clothing products.

1. Situation: Wearing apparel represented a major market for cotton amounting to 7.6 million bale equivalent in 1964, of which cotton supplied 4.6 million bales. However, the competition by man-made fibers in this area is especially strong due to the wide variety of specific fiber properties available in the synthetics. Research to enhance the comfort, durability, and other desirable qualities, and to impart additional properties required in specific end-use products, is essential to maintain or increase cotton's share of this lucrative market. Listed below are 20 consumer products which, based on market potential, competitive pressure, and technical feasibility, offer the best opportunities today for cotton clothing product research. The full research effort needed on any one of these products may call for the solution of several separate and distinct problems, each in turn justifying more than one research approach. Thus, the total program of any product, if it is to be adequate, will likely be large and will grow larger as the project moves into the expensive stages of pilot-plant operations and adaptation to commercial production.

2. Objective: To increase consumption of cotton through development of specific products to meet consumer demand.

3. Research approaches:

- a. Dress shirts - men's and boys'.
- b. Work trousers - men's and boys'.
- c. Work shirts - men's and boys'.
- d. Woven sport shirts - men's and boys'.
- e. Dress and sport trousers and outerwear shorts - men's and boys'.
- f. Woven dresses - women's and children's.
- g. Woven blouses - women's and children's.
- h. Knit dresses - women's and children's.
- i. Knit outerwear shirts, including sweat - men's and boys'.
- j. Fabric rainwear - men's, women's, and children's.
- k. Slacks and shorts, including knit - women's and children's.
- l. Hosiery - men's, boys', women's, and children's - excluding women's full length.
- m. Washable service apparel - women's.
- n. Knit underwear - men's and boys'.
- o. Sport coats - men's and boys'.
- p. Suits - men's and boys'.
- q. Skirts - women's and children's.
- r. Sweaters - men's, women's, and children's.
- s. Dungarees and jeans - women's and children's.
- t. Woven slips, petticoats, and nightwear - women's and children's.

4. Character of potential benefits: Retention of or increase in cotton's share of substantial consumer markets.

J. Better household products.

1. Situation: Household textile markets are exceeded only by those for apparel. Domestic consumption of cotton in these products amounted to 2.7 million bales in 1964, compared to the total market of 5.5 million bale equivalents. Thus, there are numerous opportunities for increasing consumption of cotton through research to impart specific end-use properties desired by the consumer. Listed below are seven consumer products which, based on market potential, competitive pressure, and technical feasibility, offer the best opportunities today for cotton household product research. The full research effort needed on any one of these products may call for the solution of several separate and distinct problems, each in turn justifying more than one research approach. Thus, the total program on any product, if it is to be adequate, will likely be large and will grow larger as the project moves into the expensive stages of pilot-plant operations and adaptation to commercial production.

2. Objective: To increase consumption of cotton through development of specific products to meet consumer demand.

3. Research approaches:

- a. Sheets and pillowcases.
- b. Tufting yarns for rugs and carpets.
- c. Backing for tufted rugs and carpets.
- d. Drapery and upholstery fabrics - household.
- e. Curtains, excluding shower curtains.
- f. Blankets.
- g. Bedspreads, excluding tufted.

4. Character of potential benefits: Retention of or increase in cotton's share of substantial consumer markets.

K. More competitive industrial products.

1. Situation: Cotton consumed in industrial products amounted to 1.5 million bales in 1964, while the total market for these products was equivalent to 6.0 million bales. The situation on industrial products is analogous to that on consumer products listed under research units I and J above. Based on similar considerations, six industrial product categories which offer the best opportunities for cotton are listed below.

2. Objective: To increase consumption of cotton through development of specific products to meet industrial needs.

3. Research approaches:

- a. Industrial rubber goods (tires, belting, hose).
- b. Tents.
- c. Bags.
- d. Cordage and twine.
- e. Awnings.
- f. Tarpaulins.

4. Character of potential benefits: Retention of or increase in cotton's share of substantial industrial textile markets.

L. More efficient cottonseed processing.

1. Situation: Factors involved in seed crushing, the processes by which cottonseed is separated into its primary products, oil, meal, linters, and hulls, affect the yield and quality and, hence, the value of these products, which in 1964 aggregated about \$420 million at the processor's level. The present state of seed crushing technology owes much to past research and development activities in this area. There is, however, need for additional research to improve processing efficiency and to afford higher quality oil and meal products of greater utility through work toward objectives such as:

- a. Prepressing separations, including air fractionation to remove bad seed; trash removal from seed; removal of linters from seed; cleaner separation of meats from hulls; and air fractionation to remove pigment glands.
- b. Improvement of oil removal by prepressing or screw pressing equipment.
- c. Removal of oil by extraction with solvent, singly or in combination; fractionation to remove pigment glands using liquid cyclone equipment.
- d. Removal of inherent or adventitious components that adversely affect suitability for certain feed or food uses.
- e. Finding new or expanded uses for linters and hulls.

2. Objective: To develop improved processes for, and products from, cottonseed crushing.

3. Research approaches:

- a. Improvement of prepressing separations.
- b. Improvements in mechanical processing.
- c. Improved, more efficient solvent extraction processes.
 - 1) Single solvent systems.
 - 2) Mixed solvent systems.
 - 3) Dual solvent systems.
- d. Improved uses for linters and hulls.

4. Character of potential benefits: More economical processes for crushing cottonseed and improved quality of major products to expand their utilization.

M. New and improved feed and industrial products from cottonseed.

1. Situation: Cottonseed oil historically accounts for about 55 percent of the value of products produced from cottonseed, and meal about 33 percent. The market demand for these two products thus establishes the price that processors can pay for cottonseed. Cottonseed meal's use traditionally has been in animal feeding applications. It was at one time considered to be suitable only for feeding to ruminant animals, but accumulated research findings have demonstrated that when properly processed, it can be fed to poultry and swine. While substantial progress has been made in this direction, further research is needed to develop high quality meals that can be fed without restriction to all animal species.

In the area of industrial uses, the potential for cottonseed products is virtually untapped, particularly the uses for cottonseed protein products. Cottonseed proteins inherently possess physicochemical properties that could be near ideal for some industrial uses, such as sizings, etc. Basic and applied research is needed to provide information to adapt cottonseed proteins to the many potential industrial uses.

Cottonseed oil traditionally has gone into food product uses although the oil and its derivatives have found some industrial outlets. For example, its usage in industrial or inedible products averaged about 13 million pounds in 1964, accounting for only 0.3 percent of total fats and oils consumed, thus affording considerable potential for increased usage. Cottonseed oil offers unique advantages for industrial use because its predominant saturated acid is palmitic. Further, since it contains no linolenic acid, fractionation of the fatty acids is less complicated than for competing oils. Cottonseed oil fatty acids derived from soapstock, a byproduct of refining, have filled past needs in the area of industrial utilization. The development of new and better products, however, could provide a profitable industrial outlet for the same 25 percent of cottonseed oil too dark or too high in free fatty acids for fully satisfactory use in edible products. Success in these endeavors offers the best promise for retaining present markets for cottonseed oil in the face of competing materials, as well as for providing outlets for projected increases in cottonseed production.

2. Objective: To develop improved processes for and products from cottonseed oil and meal for feed and industrial uses.

3. Research approaches:

a. Oil and oil derivatives for industrial uses.

b. Improved meal quality for unrestricted feeding to all animal species.

c. Industrial protein isolates and concentrates to take advantage of properties of cottonseed proteins.

4. Character of potential benefits: Improved feed products from cottonseed will make this protein supplement available for feeding animals without restrictions. Improved processes and products from cottonseed oil and meal for industrial uses are needed to take advantage of the favorable fatty acid structure of the oil and the physicochemical properties of cottonseed proteins.

Recommended Research Effort, RPA 407

It is recommended that the total scientist man-year research effort (USDA, SAES, and industry) be as follows:

<u>Research Unit</u>	<u>Fiscal Year</u>		
	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A	35	40	80
B	25	35	70
C	20	25	50
D	53	105	150
E	52	105	150
F	23	45	60
G	15	30	40
H	7	15	20
I	32	48	80
J	32	48	80
K	16	24	40
L	10	15	20
M	20	25	30
Total	340	560	870

In view of this total requirement, the recommended USDA and SAES research effort is shown in Table 16 below:

TABLE 16.--Scientist man-year research requirements, RPA 407

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Textile production efficiency	USDA	11.0	16.0	30.0	60.0
	SAES	1.0	1.0	1.0	1.0
	Total	12.0	17.0	31.0	61.0
B. Higher manufacturing quality	USDA	10.0	12.0	24.0	50.0
	SAES	0.4	1.0	1.0	1.0
	Total	10.4	13.0	25.0	51.0
C. Improved finishing efficiency	USDA	1.0	2.0	6.0	10.0
	SAES	0	0	0	0
	Total	1.0	2.0	6.0	10.0
D. Durable press, warmth and other resilience properties	USDA	36.6	35.0	70.0	90.0
	SAES	0	5.0	10.0	20.0
	Total	36.6	40.0	80.0	110.0
E. Fire-, weather-, water-resistance and other chemical properties	USDA	22.0	35.0	70.0	90.0
	SAES	0	5.0	10.0	15.0
	Total	22.0	40.0	80.0	105.0
F. Luster, smoothness and other surface properties	USDA	8.0	15.0	30.0	40.0
	SAES	0	3.0	6.0	10.0
	Total	8.0	18.0	36.0	50.0
G. Strength, low bulk, sheerness and related properties	USDA	8.0	10.0	20.0	30.0
	SAES	0	2.0	4.0	6.0
	Total	8.0	12.0	24.0	36.0

(continued)

TABLE 16.--Scientist man-year research requirements,
RPA 407 (continued)

<u>Research Unit</u>	<u>Agency</u>	<u>1966</u> <u>(SMY)</u>	<u>1969</u> <u>(SMY)</u>	<u>1972</u> <u>(SMY)</u>	<u>1977</u> <u>(SMY)</u>
H. Abrasion and linting resistance and related properties	USDA	8.0	5.0	10.0	15.0
	SAES	0	1.0	2.0	5.0
	Total	8.0	1.0	12.0	20.0
I. Improved clothing products	USDA	20.0	24.0	36.0	50.0
	SAES	1.0	1.0	2.0	3.0
	Total	21.0	25.0	38.0	53.0
J. Better household products	USDA	0	8.0	16.0	40.0
	SAES	1.0	1.0	2.0	3.0
	Total	1.0	9.0	18.0	43.0
K. More competitive industrial products	USDA	10.0	18.0	20.0	30.0
	SAES	0	0	1.0	2.0
	Total	10.0	18.0	21.0	32.0
L. More efficient cottonseed pro- cessing	USDA	2.0	6.0	8.0	10.0
	SAES	1.0	1.0	2.0	3.0
	Total	3.0	7.0	10.0	13.0
M. New and improved feed and industrial products from cottonseed	USDA	2.8	10.0	12.0	15.0
	SAES	1.4	5.0	7.0	10.0
	Total	4.2	15.0	19.0	25.0
RPA 407 Total	USDA	139.4	196.0	352.0	530.0
	SAES	5.8	26.0	48.0	79.0
	Total	145.2	222.0	400.0	609.0

Facility Needs to Support the Recommended Research Effort, RPA 407

Federal new construction at New Orleans will provide two floors for improved mechanical and finishing pilot-plant facilities to relieve overcrowded conditions in the present building. However, the new construction was designed so that there could be subsequent addition of two more floors (for a total of four) and extension to the east to provide needed pilot-plant facilities for new product development. These facilities would provide space for approximately 100 of the projected 454 SMY increase by 1977 at an estimated cost of \$2,500,000 as follows:

Addition of two floors	30,420 square feet	\$1,500,000
Extend building to east	18,720 square feet	<u>1,000,000</u>
		\$2,500,000

To provide for the remaining 291 SMY Federal effort projected would require extension of current facilities to provide a new wing to the north together with appropriate connecting structure totaling 145,500 square feet (500 square feet per SMY for an estimated cost of \$7,275,000 (\$50 per square foot) based on current cost of laboratory construction.

In addition to the new buildings outlined above, it is estimated that approximately \$1,000,000 for specialized pilot plant and laboratory equipment and instruments will be required.

The facility requirements for the projected State Agricultural Experiment Station program cannot be precisely determined but current facilities are generally inadequate. On the basis of projections for 73 additional scientists and an estimated \$25,000 for facilities to support each scientist (allowing 500 square feet per SMY and an estimated cost of \$50 per square foot in construction costs), the total SAES needs for this RPA will aggregate about \$1,825,000 by FY 1977.

Research Problem Area 408 - Quality Maintenance in Marketing Field Crops

Situation

Maintenance of cotton and cottonseed quality against the inroads of moisture, chemical changes, and other quality-deteriorating factors is important to minimize costs in storage and distribution. The resources required to produce commodities lost or damaged in the marketing process are wasted. In addition, there are serious losses in end-use quality that occur as a result of physical and chemical changes in transportation and storage of cotton and cottonseed products.

These facts rather obviously suggest investigations to determine proper packing techniques, optimum storage conditions, including control of temperature, moisture and atmosphere, and correct handling procedures. Under improper storage conditions, cotton lint may change in color, and/or other fiber properties which affect ultimate utilization. Similarly, cottonseed, cottonseed oil, and cottonseed meal may deteriorate in quality from the standpoint of food and feed uses.

In addition, the rapid mechanization of cotton production no doubt introduces new problems in storage and handling of cotton that differ markedly from the problems posed by cotton produced with traditional practices.

Research on quality maintenance should also include the development of techniques for measuring quality and changes in quality.

Specific Research Units, RPA 408

A. Measurement of factors affecting cotton quality.

1. Situation: Technological advancement in production, harvesting, and ginning of cotton brought on by mechanization has resulted in changes in the quality of cotton fiber which are not recognized by present methods of quality evaluation. Mill operators, both domestic and foreign, have reported that these changes have reduced the spinning quality of cotton, thus increasing processing costs and lowering the value of finished products. Precise information is needed on the processing performance and manufactured product quality of cotton which has been subjected to various production, harvesting and ginning practices. New and improved techniques, devices, and procedures for measuring quality factors of cotton fiber are needed.

2. Objective:

- a. To develop methods and techniques for measuring characteristics of cotton which determine its quality.
- b. Define and quantify relationships of fiber properties and manufacturing performance.

3. Research approaches:

- a. Investigate electronic techniques as a method of measuring spinning strength and spinning strength variability as related to spinning end breakage.
- b. Automation and improvement of the Fibrosampler.
- c. The effects of variety, production location, growing conditions, and harvesting methods on processing performance will be studied.
- d. The effects of fiber conditioners on the chemical properties of cotton.
- e. Determine the physical and chemical properties of certain cottons having a tendency to cause "fiber-lap" and machinery contamination in yarn manufacturing.
- f. Determine the effects of various fiber properties spun under optimum drafting mechanism settings on spinning performance and product quality.

4. Character of potential benefits: Protection of cotton against quality deterioration in storage and marketing.

B. Improved techniques and equipment for handling and storing baled cotton in warehouses.

1. Situation: A major portion of the cotton marketed annually is now mechanically harvested. This has resulted in baled cotton moving to warehouses at a rapid rate, and techniques and equipment formerly used by warehousemen are no longer adequate. The increasing shortage and prohibitive cost of labor for manual handling requires further development of more efficient techniques and equipment. There is increasing concern about maintaining the quality of stored cotton, particularly the cleanliness of the bale surface and the moisture content within the bale. Although a satisfactory moisture content can be maintained in stored cotton in warehouses located in humid climatic areas, this is not possible in arid climatic areas. An economical method to humidify storage compartments would permit their use for 10 instead of six months each year. There is a need for developing special storage procedures and equipment to maintain the desired moisture content of this cotton.

2. Objective: Develop improved techniques, equipment, and facilities to handle, condition, and store baled cotton to reduce unit handling and operating costs and facility construction costs and to maintain cotton quality.

3. Research approaches:

- a. Laboratory studies will be conducted to determine optimum environmental conditions for storage and to develop improved bale coverings and strapping.
- b. Studies will also be conducted at warehouses to develop new handling and storage procedures with special emphasis on operating practices in the Southwest.

4. Character of potential benefits: Reduction in handling and storage costs and savings from damage in storage.

C. Improved techniques and equipment for long-term storage of baled cotton.

1. Situation: Historically, the production and marketing of cotton and its manufacture into textiles have contributed greatly to the national economy. Recently, however, the introduction of man-made fibers, rising costs and competition of foreign cotton have contributed to a reduction in the U. S. consumption of cotton. Meanwhile, cotton production has remained fairly stable. Thus, the dwindling consumption each year has resulted in storing many bales of cotton for longer than a normal period of time, extending to several years. There is increasing concern about providing adequate protection and proper storage conditions to maintain the market quality of this cotton.

2. Objective: Develop improved techniques, equipment, and facilities to condition and store baled cotton to maintain its quality during long-term storage periods.

3. Research approaches:

- a. Laboratory studies will be conducted to determine the storage requirements of cotton as to environmental conditions.
- b. Full-scale studies at warehouses will be conducted to extend the laboratory studies and to determine stacking patterns of the baled cotton and handling techniques.

4. Character of potential benefits: Maintenance of fiber properties.

D. Improved techniques and equipment for handling, drying, and storing cottonseed.

1. Situation: Some six million tons of cottonseed each year must be handled and stored from the time of harvest until it is processed or planted. Recent methods require considerable manual handling of the cottonseed, a slow, time-consuming method which grows more expensive with increasing wage rates. Recent studies show cottonseed is susceptible to contamination by toxin-producing molds during handling and storage in commercial facilities. Often, seed moving to commercial storage is too moist and hot for safe storage. Maintaining the quality of this seed presents problems arising from enzymatic activity and other deterioration. Excessive seed moisture and temperature also increases the seed's susceptibility to toxin-producing molds. Engineering research is needed to determine requirements for conditioning such seed to maintain its market quality.

2. Objective: Develop improved equipment and more efficient techniques for handling cottonseed into, within, and out of commercial storages to reduce handling costs. Improve techniques, operating procedures, and equipment for conditioning and treating cottonseed, including operations such as drying, precooling, cleaning, and protective treating, prior to storage to maintain its quality.

3. Research approaches:

- a. Laboratory studies will be used to test theoretical concepts of drying and cooling as applied to cottonseed.
- b. Pilot-scale equipment then will be developed and tested and extended to full-scale equipment which will be tested under commercial operating conditions.

4. Character of potential benefits: Maintain quality and reduce costs of marketing cottonseed.

Recommended Research Effort, RPA 408

TABLE 17.--Scientist man-year research requirements, RPA 408

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Measurement of factors affecting cotton quality	USDA	7.6	18.0	19.0	23.0
	SAES	2.0	5.0	5.0	5.0
	Total	9.6	23.0	24.0	28.0
B. Improved techniques and equipment for handling and storing baled cotton in warehouses	USDA	0	0	0	2.0
	SAES	0	0	0	2.0
	Total	0	0	0	4.0
C. Improved techniques and equipment for long-term storage of baled cotton	USDA	0	0	0	2.0
	SAES	0	0	0	2.0
	Total	0	0	0	4.0
D. Improved techniques and equipment for handling, drying, and storing cottonseed	USDA	1.0	1.0	1.0	3.0
	SAES	0	0	0	0
	Total	1.0	1.0	1.0	3.0
RPA 408 Total	USDA	8.6	19.0	20.0	30.0
	SAES	2.0	5.0	5.0	9.0
	Total	10.6	24.0	25.0	39.0

Facility Needs to Support the Recommended Research Effort, RPA 408

Additional facilities will be needed to carry out the proposed increase in research:

1. Fiscal Year 1969 - Construction of a laboratory at Clemson, South Carolina	\$2,800,000
2. Fiscal Year 1972 - Construction of a laboratory at Lubbock, Texas	108,333
3. Fiscal Year 1973 - Construction of a laboratory at Stoneville, Mississippi	<u>122,222</u>
Total	\$3,030,555

Research Problem Area 501 - Improvement of Grades and Standards

Situation

Grades and standards are designed to describe characteristics of a product which affect its value to users. Thus, effective grades and standards assist buyers in obtaining product characteristics they desire and sellers in obtaining appropriate compensation for what they sell.

Many grades and standards are not as useful as they could be because they do not adequately cover the characteristics desired by users. Others could be improved by the substitution of instrument measurements of characteristics for the subjective techniques now used.

The development of instruments for measuring fiber properties in cotton would be one method of increasing objectivity in cotton classing. In turn it would be necessary to use instrument value in pricing cotton.

More objective measures are also needed for use in describing quality of cottonseed oil and meal.

Specific Research Units, RPA 501

A. Measuring quality factors and value of cotton.

1. Situation: The consensus of most segments of the cotton industry is that existing methods and procedures of cotton quality evaluation do not provide for measurement of all qualities significantly affecting use value of cotton, nor a means of reflecting these value differences in prices. The need for improvement in evaluation becomes more urgent as a result of continuing technological changes in production, marketing, and processing which increase the need for more exact measurements of all fiber properties in order to meet the more stringent demands upon cotton fibers. The problem is intensified further by the development and continuing improvement in quality of man-made fibers which enhance their competitive position relative to cotton. The failure to develop adequate grades and standards for use in trading undermines the ability of prices to act as effective guides to production and marketing and the optimal selection of qualities of cotton to meet the requirements of each end product.

2. Objective: To objectively measure factors affecting cotton quality and establish corresponding value.

3. Research approaches:

- a. Determination of all significant factors affecting the costs of processing cotton fibers or the value of cotton products.
- b. Development of more adequate quantitative measures of the relationship of variation in quality factors and alternative processing techniques to processing performance and cost, quality, and value of end products.
- c. Development of fiber test instruments to measure color, trash, length, fineness, and strength, and set up a production line testing system.
- d. Development of more effective pricing and market information systems for cotton based on measurable quality factors.

4. Character of potential benefits: Increased efficiency in marketing.

B. Measurement of factors affecting cottonseed quality.

1. Situation: Cottonseed is subject to deterioration in quality and loss in value through fungus damage and contamination, normal metabolic changes, and instability of its oil constituents when exposed to the atmosphere. To maintain its quality, more precise information is needed on the environmental factors which influence these changes during handling, storage, transportation, and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods for measuring quality factors need to be developed for use in inspection, grading, and standardization programs.

2. Objective: To develop methods and techniques for measuring characteristics of cottonseed which determine its quality.

3. Research approaches:

- a. Develop equipment and methods for rapid determination of available protein in cottonseed and cottonseed meal.
- b. Develop equipment and methods for accurate measurement of the oil content of cottonseed and cottonseed meal.
- c. Develop equipment and methods for relating storage deterioration factors of cottonseed oil with organoleptic measurements.
- d. Develop equipment and methods for measuring differences in thermal and chemical oxidation of stored cottonseed oils.

e. Develop equipment and methods for optical color measurement of cottonseed oil.

f. Develop methods for estimating nutritive values of cottonseed meal.

4. Character of potential benefits: Maintenance of quality and protection against losses in storage.

Recommended Research Effort, RPA 501

TABLE 18.--Scientist man-year research requirements, RPA 501

Research Unit	Agency	Fiscal Year			
		1966 (SMY)	1969 (SMY)	1972 (SMY)	1977 (SMY)
A. Measuring quality factors and value of cotton					
	USDA	1.8	9.0	12.0	13.0
	SAES	0.8	1.0	2.0	2.0
	Total	2.6	10.0	14.0	15.0
B. Measurement of factors affecting cottonseed quality					
	USDA	0.5	11.0	13.0	18.0
	SAES	0.1	2.0	2.0	2.0
	Total	0.6	13.0	15.0	20.0
RPA 501 Total					
	USDA	2.3	20.0	25.0	31.0
	SAES	0.9	3.0	4.0	4.0
	Total	3.2	23.0	29.0	35.0

Facility Needs to Support the Recommended Research Effort, RPA 501

Additional facilities needed to implement this research program would consist primarily of office space for scientists and aids. The addition of 32 scientists at \$6,000 per man would indicate a need of \$192,000 for facilities.

Research Problem Area 504 - Physical and Economic Efficiency in
Marketing Field Crops

Situation

Improving physical and economic efficiency in marketing field crops is of critical importance in maintaining the rapidly rising levels of living in the United States. It will also help to prevent a further decline in the farmer's share of consumer expenditures. Rising costs of labor and other inputs and increasing demand by consumers for added services tend to increase marketing costs, and frequently restrict the farmer's market. Research on improved physical and economic efficiency in marketing and processing will help to offset these forces.

Specific Research Units, RPA 504

A. Firm efficiency and marketing costs for cotton.

1. Situation: Costs of marketing cotton and manufacturing cotton fabrics account generally for over 15 percent of the consumer dollar spent for cotton products compared to about 14 percent going to farmers. Opportunities for reducing these costs, which have more than doubled in the past two decades, appear to equal the opportunities for reducing farm production costs. Reductions of costs in the marketing-manufacturing area would contribute directly to improving the competitive position of cotton without increasing production, depressing prices, or contributing to the problems of excessive supplies.

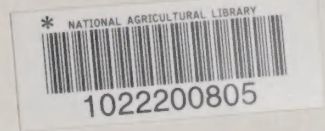
Research in this area should include work designed to reduce costs and increase the operating efficiency of individual firms and functions involved in moving cotton from farms through fabric manufacturing plants. In developing this research, care must be taken that optimization of one function does not have a deleterious effect on other functions. For example, minimization of ginning costs might substantially increase transportation, warehousing, or manufacturing costs. It is essential, therefore, that the research be designed to determine the optimum complete production-processing-manufacturing system for cotton. Without consideration of the complete system, suboptimization is likely to occur.

2. Objective: To improve efficiency in marketing cotton and lower marketing costs.

3. Research approaches:

- a. Determination of the optimum size, location, type, and method of operation of individual plants and firms performing ginning, warehousing, and merchandising functions and the organization of the industry which will minimize the total marketing bill. Such research should include studies to:
 - 1) Evaluate alternative designs of machinery and plant layout.
 - 2) Determine the feasibility of reducing costs through vertical integration of functions such as seed cotton or lint storage with ginning and cottonseed processing.
 - 3) Develop improved sampling equipment and methods and explore the use of alternative type samples in merchandising.
 - 4) Explore possible advantages, problems, and steps involved in adoption of single density bales.
 - 5) Determine the feasibility of net-weight trading, including standardized moisture and foreign matter.
 - 6) Develop spatial equilibrium models to indicate location of ginning and storage facilities which would provide adequate services for growers and minimize total handling costs.
- b. Determine the feasibility of revitalizing future markets and improving merchandising practices.
- c. Determine possibility of reducing cotton textile manufacturing cost by providing more adequate quality measures to promote better selection of cotton to meet processing and end-product requirements.
- d. Develop economic-engineering data indicating optimum processing organization for various qualities of cotton and types of end products so as to lower manufacturing costs for cotton textiles relative to man-made fabrics.
- e. Determine qualities of cotton which, when processed with the optimum organization, will permit operating at higher speeds with minimum ends down, loom stops, and occurrence of seconds.
- f. Explore the possibilities of increasing efficiency in cotton and cottonseed cooperatives and the expanded use of these facilities.

4. Character of potential benefits: Lower marketing costs.



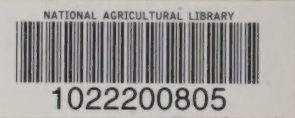
Recommended Research Effort, RPA 504

TABLE 19.--Scientist man-year research requirements, RPA 504

<u>Research Unit</u>	<u>Agency</u>	<u>Fiscal Year</u>			
		<u>1966</u> (SMY)	<u>1969</u> (SMY)	<u>1972</u> (SMY)	<u>1977</u> (SMY)
A. Firm efficiency and marketing costs for cotton	USDA	13.0	14.0	16.0	21.0
	SAES	2.4	3.0	6.0	12.0
RPA 504 Total		15.4	17.0	22.0	33.0

Facility Needs to Support the Recommended Research Effort, RPA 504

Additional facilities needed to implement this research program would consist primarily of office space for scientists and aids. The addition of 18 scientists at \$6,000 per man would indicate a need of \$108,000 for facilities.



TABLES

1. Selected changes in the U. S. cotton industry 1950 to 1965.
2. Cotton and cottonseed research requirements to attain LRS projection.
3. Comparison of the LRS and the Cotton and Cottonseed Task Force recommendations.
4. Scientific man-year research requirements estimated by the Cotton and Cottonseed Task Force.
5. Research facility needs estimated by the Cotton and Cottonseed Task Force.
6. Cotton and cottonseed research program projections and potential source of support.
7. Potential fund support for Cotton and Cottonseed Research Program.
8. Scientist man-year research requirements, RPA 207.
9. Scientist man-year research requirements, RPA 208.
10. Scientist man-year research requirements, RPA 209.
11. Scientist man-year research requirements, RPA 307.
12. Scientist man-year research requirements, RPA 308.
13. Scientist man-year research requirements, RPA 309.
14. Scientist man-year research requirements, RPA 405.
15. Scientist man-year research requirements, RPA 406.
16. Scientist man-year research requirements, RPA 407.
17. Scientist man-year research requirements, RPA 408.
18. Scientist man-year research requirements, RPA 501.
19. Scientist man-year research requirements, RPA 504.